THE

GREAT INVENTIONS:

THEIR HISTORY,

FROM THE EARLIEST PERIOD TO THE PRESENT.

THEIR INFLUENCE ON CIVILIZATION,

ACCOMPANIED BY SKETCHES OF

LIVES OF THE PRINCIPAL INVENTORS;

THEIR LABORS, THEIR HARDSHIPS AND THEIR TRIUMPHS.

BY

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ILLUSTRATED.

J. A. RUTH & CO.,
PHILADELPHIA AND CHICAGO.
1883.

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PREFACE.

IT is safe to assert that no class of effort has been as pre-eminent in the development of civilization as that of invention. It has given us substantially everything we possess which distinguishes us from our savage ancestors. When invention has slept, humanity has slept also, or else has retrograded towards barbarism. Effort so conspicuous, so deserving of commendation is entitled to more substantial recognition than it has yet received.

Hitherto what has been said of invention has been scattered through the books. Nobody has apparently thought it worth while to collect what may be said of inventors and their works as has been done with other classes of efforts and the men who were prominent in their production. Frequently this has been done in cases where the classes of results have been far less influential than invention in the part played in the drama of the world's progress. It is to remedy this injustice that this work has been prepared.

It will undertake to show how civilization has been influenced by invention, and how the latter has been the leader and not the follower of the former. It will

endeavor to give faithful sketches of a class of men who have often been derided, generally misunderstood, and as a rule, underpaid for their great services.

Another of its objects is to correct a popular ignorance in regard to the origin of inventions. It will endeavor to show that there is a widely-diffused belief as to the beginning of many practical appliances which is without foundation, as for instance that Stephenson constructed the first locomotive, that Fulton was the "inventor" of the steamboat, that Jenner was the first to use vaccine matter as a remedy against small-pox. Innumerable errors of this kind are in existence, and should be corrected, not only in the interests of truth, but that credit for these great results should be distributed where they belong.

These are the practical reasons why this work has been undertaken and given to the public. It is believed to be the first attempt to group inventors and inventions within the compass of a book. In this particular, it is believed that it will have an especial value as a work of reference, as dates have been carefully prepared, and occurrences so located that a very large class of valuable information is made available, at sight, for those who may be in search of it. It is also thought that the sketches of the lives of inventors of prominence, which are woven in the woof of the book, will possess no small value, as they present models which will be of the highest utility to the American youth during the progress of their development.

F. B. W.

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THE GREAT INVENTIONS.

CHAPTER I.

THE BIRTH AND THE CHILDHOOD OF A GIANT.

ONE of the grandest rôles in the great drama of Human Progress has been filled by Invention. Invention and civilization have come up out of the ages, hand in hand. They stand to each other in the relation of cause and effect, in which they act as alternately the one and the other. One day, invention creates on the demand of civilization; and the next day, the latter, impelled by the former, makes a long stride in advance.

There are many factors to be considered in an elaboration of the growth of the world—they are innumerable, in fact; but the peer of them all, and, in many phases, the chief of them, is to be found in invention. It has made the waters a highway which men traverse as they do solid land; it, and its other self, discovery, have lifted the nations from skins and caves to royal purple and palaces. The air of this planet, echoing the hum of spindles, the soughing of locomotives, the roar of the speeding trains, the clang of hammers, the murmurs of the telegraph wires, and all the innumerable clamors of machinery, chants to all its remotest limits, a hymn of praise over the labors of invention.

Fancy for a single moment what this world would

be if deprived of the inventions of the Stephensons, the Morses, the Fultons, and others of their kind! The slender wires along the sky-line would vanish; the tapping of the telegraph sounder would cease; the gas-jets would die out; the clack of the looms would be replaced by silence; the ocean would become an awful, an impassable desert. The world would wander in sloughs of mud. Pestilence would take the place of cleanliness and health. The stars would become mysterious, and menacing eyes glaring at us from the fathomless blue. Hovels and caves would come where homes of marble and beauty now stand. The sun would resolve itself into a ball of fire revolving about us; the Gothic churches, with all their freightful memories, would sink as into the yawning abyss of an earthquake. Men would hunt for caves for dwelling-places, and clothe themselves with the skins of animals slain in hand-to-hand conflicts.

Savagery pure and simple would supplant all that there is of art, of the beautiful; and the world would become a desert in which man would skulk, and hide, shivering at the unending unknown which would everywhere envelop him.

This is but the faintest of outlines of the condition to which we should be reduced were we suddenly deprived of all that invention has conferred on us; and from this, we obtain somewhat of an idea of what we would be had not inventive genius, at the very infancy of the race, come to our assistance, and led us from the inclement past into the warmth and brightness of the present.

The birthplace of the beneficent genius which has done so much for man is not even known. It is less so than in the case of the Greek poet, of whom it was said:

"Seven cities warr'd for Homer being dead;
Who living, had no roofe to shrowd his head."

But we may infer somewhat as to its origin. Somewhere it was in the misty, the unknown past. Somewhere among the caves in which dwelt the primitive man. The locality was near some stream, when the earth still bore the wounds inflicted on its bosom by the great glacier that moved down on it from the Arctic areas. In some gloomy cave lay the embryo of the genius which was to revolutionize the world. About were the colossal mastodon, the enormous ant-eater, the vast armadillo, ox-like as to size, and toothed like a shark as to strength of jaw and cruel keenness of its armament. Here, amid what was but a faint resemblance of man, invention was needed and it was born. It was needed to enable the groveling savage to save his apparently worthless life; it was needed to protect him against the monsters which patrolled the land, and waded and swam in the turbid pools, and that breasted the fierce torrents of the diluvial period. It was needed to protect him against the cold of winter, the summer heats, the consequences of floods, the results of wounds acquired in naked conflicts with beasts of prey, and to enable him to commence that career to which he was destined.

Thus needed, invention came to the relief of man. What was the very first of its creations, we do not know. Possibly a hatchet of stone; possibly a simple club, a weight at the end of a stick. A fallen limb was probably the first weapon of offence and defence adopted by primitive man; a chance stick whose knotted end suggested the knob at the extremity of a war club. From the possession of this simple instrument came the suggestion to weight the end with something more enduring than wood. Hence the stick with a stone somehow fastened to the end. Almost inevitable after this was the suggestion of a cutting edge to one face of the stone. In time, it became evident from experience that

the harder the stone, the more endurable; hence the flint, hardest of all substances known to the primitive world. It is these rude hatchets which first came into existence, and their originator was the genius of invention. They were as much an invention as the ponderous battle-axes of a later period; as much so as the breech-loading gun of to-day, which tosses a missile of a ton's weight, a distance of from fifteen to twenty miles.

The innumerable tumuli which have been unearthed in late years contain these primitive weapons without limit. They are found almost everywhere; in this country in the greatest profusion. Their age is not known. They may date back to a period not more remote than a score, or two scores of centuries. In the excavations of the lake dwellings of Switzerland these weapons are found in abundance, and with them other evidences that man was on the highway of advancement. In one of them at Moosseedorf, there were a knife made of a boar's tooth; a bone chisel, and bone knife; an awl of the same material; a saw of flint; a harpoon of a stag's horn; and a fish-hook and needles constructed from the tusks of the boar. At what age the making of these weapons occurred makes no difference as to the fact under consideration; they were pure inventions, and were the first step which was taken by this genius in the wonderful career which was before it.

It is a long way from the harpoon wrought from the horn of a stag to the harpoon-gun now in use; long was the route, and numerous and vexatious the delays; but, as we shall see, the route has been traveled; the centuries have all been bridged and crossed; all the centuries which lie between us and the troglodytes who existed somewhere in the misty distance of prehistoric ages. But, in this connection, it should be borne in mind that there is no period or date which may be assigned as the

PRIMITIVE MAN.

chipped flint, or palæolithic age; that is to say, it is not the fact that simultaneously among all the tribes, all over the earth, men used roughly-fashioned flints for implements of the war or the chase. On the contrary, this palæolithic period is still in existence. It was in existence when Columbus discovered America, for he found a continent peopled by men who knew substantially nothing of the metals, and who still used flints for spear and arrow-heads as did the tribes whose traces are to be found as far back as the time when the northern half of Europe was covered with ice. Even to-day there are peoples in the southern portion of South America who have in no material sense advanced beyond the period when "the Thames was a tributary of the Rhine, the English channel not yet in existence, and Britain only existed as part of a continent which stretched away uninterruptedly northward towards the Arctic circle." *

The advent of man in Northern Europe is said by an eminent authority to have occurred at a period "when the mammoth and the tichorine rhinoceros still roamed its forests, and the great cave-tiger and other extinct carnivora haunted its caverns; when the gigantic Irish elk, the reindeer, the musk-ox, and the wild horse were objects of the chase; and the hippopotamus major was a summer visitor to the Seine, and the Thames."

Invention having enabled man to provide for his most pressing wants; having put him in a position to slay the animals on which he fed, to defend himself from the attacks of foes, and to take the initiative against his enemies, now went a step further. It began to minister to his taste, to develop the artistic in his nature. The step was a short one; but it was an initial one of a

* *Prehistoric Man*, by Dr. Daniel Wilson.

march that has continued with scarcely an interruption through all the centuries to the present moment. This next movement on the part of invention was the polishing, and the finish of the rude weapons already formed. The first implements of the primitive man were rudely fashioned—the knife, the spear-head, the hatchet being chipped from pieces of flint; the next was to fashion them so that they would please the eye. The roughness of the surfaces were removed by rubbing; the edges were ground to a condition of keenness, and the pointed instruments were brought to a polished point. The time which elapsed between the age of the two kinds of weapons is unknown. It may have been thousands of years; but however great or small the intervening space, it is sufficiently marked to separate two very defined ages, known as the palæolithic, and the neolithic ages; the former referring to the rough, and the latter to the polished instruments. The specimens found of the polished implements exhibit a vast amount of taste, many of them being fashioned and finished in a most elaborate manner.

Having taken man in hand, invention was persistent in continuing its work. Copper was discovered by some of the wandering tribes, or in some way fell under their notice, and finding it hard, and yet more easy to work than flint and stones, it speedily became of general use. This was but a transition stage, for, in some way it was discovered that a more valuable material was to be found in copper in which a little tin had been melted and thereupon ensued the age of bronze. "This sequence," referring to the flint stone, copper, and bronze periods, "affords an interesting and important proof of progress in the earliest phases of civilization, evinced in the ingenuity and skill, and the adaptation of power to the practical purpose displayed in

these implements by man in all countries, in those early ages." *

In one sense, civilization had already commenced when invention had elaborated the alloy of bronze, and its fashioning into implements, utensils and ornaments. "The beginning of civilization," says Sir H. Davy, "is the discovery of some useful arts by which men acquire property, comfort and luxuries." The art of making bronze gave additional value to the property of men and aided them in the securing of comforts and luxuries.

There were embryo Vanderbilts in those far-off days; men who with their bronze possessions, and such other property in the shape of tents, skins, and possibly some domesticated animals, were as much above the masses, who yet fished with hooks of bone, and stabbed with spears of flint, as a Gould is above the coal-heavers in the matter of possessions.

The bronze age and its predecessor, the stone age, may have had no possible connection; and what was learned by one may have had no relations with what was acquired by the other; but it is still the case that the latter was a vast improvement over the former. The bronze age reached a very fair condition of development, judging from the "finds" of articles connected with this period. In tombs, and lake dwellings, there have been found swords with hilts, the connection between the hilt and the blade being made by rivets, and the whole ornamented in a manner which experts term "splendid." Another case is given in which a knife of the bronze epoch was found whose handle represented a human figure executed with marvellous skill as to imitation. Razors are among the things which the age possessed, whose blades were profusely ornamented. In another

* *Prehistoric Phases.* Westropp.

case, in Jutland, a tomb was opened which contained "a woolen shawl, a cloak, cap, three swords, a knife, an awl, a bodkin, a ball of amber, and a flint spear head." In this country, there have been various "finds" which throw some light on the habits and character of the men. The use of copper as a metal seems to have been known, but simply as if it had been a species of stone. The copper was mined, and was hammered and ground into the state which was required. It was made into weapons, utensils of various kinds, and ornaments.

Perhaps the most curious of all the remnants of prehistoric man are to be found in the new world. That there has at one time existed on this continent a highly civilized race does not admit of dispute. The fact has no bearing on the discussion of invention further than to demonstrate that it is possible that a race may exist, reach a high development, and leave no trace further than such as are to be found in its tumuli, and the remnants of an ancient city. Stephens, in his explorations of Central America, was very much impressed with the extent and grandeur of a civilization which had disappeared, and left no written record. He found works of art, which "proved, like newly-discovered historical records, that the people who once occupied the continent of America, were not savages." He found workmanship equal to the finest monuments of Egypt. In a dense undergrowth, he found friezes and statuary, and "ascending the steps of a vast enclosure terraced with sculptured tiers, he looked down on evidence of native energy and intellect not less wonderful than all that America has since borrowed from nations of another continent." There is one locality distributed with ruins which cover a space some twenty miles in extent. It is an extinct city. Its architecture "wrought out edifices of magnificent extent without the use of the arch;" it had

sculptures, hieroglyphic tablets, paintings, and bas-reliefs in stucco; but to this day no more is known of the nameless city or its builders, than of the significance of the hieroglyphics which mock its explorers with their tantalizing records." Their sculptures alone throw any light on the mystery, but even this saddens rather than affords relief, for all of them point unmistakably to the conclusion "that they indicate a people now lost and unknown."

Such are some of the salient facts connected with prehistoric man. They can scarcely be called "facts," but rather the probabilities of this mystic period. That men have existed cannot admit of a doubt; and that they passed through the epochs which have been outlined may not be absolutely demonstrated as may a problem in mathematics, but yet to an extent that permits little, if any doubt. There is no other history of their life than is to be gathered from the mute relics which are to be found in the tombs which they constructed, and the dwellings which have been discovered beneath the waters of various lakes. It is to be observed that the story told by these relics is a logical one, one analogous to events, facts, and occurrences within our own period. There are exhibitions of progress. We see the rude tools of the earlier men improved on by succeeding peoples. Invention is shown to be at work. It rescued man from caves, during this period, gave him comfortable clothing, taught him how to spin and weave, constructed for him utensils, polished his rude weapons, improved them in appearance, number and efficiency, taught him sculpture and carving, developed his artistic tendencies, and placed his feet on a highway which led directly in the direction of an ultimate civilization.

But after all this trouble in the interests of these people, what came of it? Who were the people thus

benefitted, and what has become of them? Were they the original Caucasian from whose Aryan branch there came the nations who were destined, in time, to take up the burdens of an energetic, progressive life, and carry them onward until the domain of civilization should be reached? Have they become extinct like the builders and occupants of Palenque, that mysterious city whose present condition indicates, "a people now lost and unknown?" We know not. On these points, history, geology, archæology, and palæontology are silent. There is a mysterious period between prehistoric man and the historic concerning which we know nothing. There are traditions which claim to explain it; there are historians who sometimes reach back and fancy they have penetrated its secrets; but they deceive themselves and those who trust their assertions. Crossing this unknown, debatable land, we shall place foot on a land which is no more a nameless one; but which has been to some extent surveyed, and whose points and shores, whose people and their work have been examined, and named so that there will be no more groping in the darkness of a No-man's land.

The description of the birthplace of the genius of invention has been a meagre one; but mystery is in accord with the genesis of the potential. Gods are not born as are men; they come out from the silent Unknown, and earthly conjecture is unable to fathom the travail of their birth, or the solemn silence which shrouds their advent into the domain of human existence.

CHAPTER II.

THE PROGRESS OF A STALWART YOUTH.

FROM the ages which have just been described at some length, to the period when iron was brought into use, there is an indefinite lapse of time, concerning whose length there is no use in speculating. Probably the first mention in writing of the beginning of the iron age is, "And Zillah, she bare Tubal-cain, an instructor of every artificer in brass and iron." (Genesis iv., 22.)

In the same connection, the assertion is made that Jubal, the half brother of Tubal-cain, was "the father of all such as handle the harp and the organ." This date is, according to the Pentateuch, nearly four thousand years ago. The Samaritan Pentateuch places it some seven hundred years later; and that of the Septuagint, and the Talmudists some seventeen hundred years earlier. But the exact date is of no consequence. The fact remains that in Jewish history the working of iron was known to the Jewish people. The reappearance of invention, after its disappearance in the age of bronze, was among the Jews. Thenceforward, for a period of some twenty-five centuries, it played a moderate part in assisting in the development of portions of the human race.

The ark of Noah is one of the first vessels spoken of in the Bible, and is probably the first case of ship-building of which the world has any knowledge; not exactly

of ship-building, for the ark is described as simply a vast, covered, floating scow; in no sense comparable to the magnificent specimens of a marine architecture which invention gave to the world at a later date. But it answered the purpose for which it was constructed, and in this respect was all that is afforded by the finest vessel that ever clove the seas. The world was not yet ready for fleets. A log hollowed out with hatchets, or burned out by fire, was furnished the people of the earlier portion of the iron age, by invention, and this answered all their wants. It taught the women to weave and spin, in a most primitive fashion, but one which met all the requirements of the populations. The men fished, fought, hunted; the women cared for the household. Their wants were simple and easily supplied. For a period of perhaps fifteen hundred years, the genius of invention had little to do save to aid in the providing of the absolute necessities of man. It assisted to clothe and feed him, to provide him shelter against inclement winters, or torrid summers—this was all. It was a season of preparation, and invention bided its time.

At varying periods after the bronze age, civilizations were developed in Europe, Asia, and Africa. In Africa rose the mighty Egyptian empire whose origin as to date is uncertain, but certainly as far back as twenty-seven centuries before the birth of Christ. Three or four hundred years later saw the beginning of the Assyrian empire, and that of Chaldea, of which famous Babylon was the seat. Eight centuries after, the Phœnicians located themselves on the east coast of the Mediterranean, and became immortal as traders, pirates, and inventors of the alphabet which we now use with but slight modifications. The civilization which found its development in Judea arose in the twentieth century B. C., and lasted till within a couple of generations of

the beginning of the Christian era. The Persian dynasty was mainly erected on the ruins of Assyrian civilization, and lasted for a little over a century, ending its career some five centuries B. C. The Chinese had their form of civilization, which was founded, as they claim, at a period so remote that no calculations can be made as to its exact date. It is usually conceded, however, that the Chinese were as early in the field as the Egyptians, that is, nearly thirty centuries before the Christian era. Greece began to take shape and prominence many a thousand years B. C., and held its lease of existence as a great civilized power for some six centuries. Rome was founded but little later than Greece; and outlived it by some eight centuries.

These include all the notable civilizations of the ancients so far as known to history. The existence of others is alleged, upon authority more or less doubtful; but, admitting all that is claimed for them, they were inferior in extent and value to those named; and, hence, need play no part in our search for the character and influences of invention.

It is common for people to sneer at the ancients on account of a certain supposed lack in the inventive faculty. It is believed that they were, as a rule, a species of splendid barbarians, given to war, to specious philosophy, to the worship of false gods, and to a morality which was at once the highest and the lowest in its character. We are apt to think of Rome as the headquarters of grand banditti; of Greece as the bome of learning, and of lasciviousness; of the Persians as effeminate idolaters, resplendent in barbaric ornamentation; and of the Egyptians as a curious people who worshipped a bull, embalmed their dead, furnished the world with mummies, and constructed pyramids, sphinxes, colossi, and invented hieroglyphics for no reasonable

purpose whatever. It is not within the design of this work to expose any fallacies of this kind further than it may happen to be the case from giving a brief outline of what was done by inventors and discoverers. In doing even this it may happen that we shall find not only that these ancient civilizations are of a much higher type than is popularly supposed, but that our civilization lacks very much being the originator of many things on which it felicitates itself, and which it believes to have been potential in aiding our lofty development.

"*Il n' a de nouveau que ce qui est oublié,*" * said a modiste when remodelling some *fanfreluche* (gewgaw) for Marie Antoinette. Possibly this remark has a wider application than was intended by the woman who uttered it. Long forgotten in the ancient civilizations are many things which to us would be new, and equally is it the fact that many things which we believe to be new were well known to peoples who lived on the Tiber, the Nile and the Euphrates. Some illustrations to show that the inventor is not exclusively a product of modern days, that we are not the originators of all that we assert ourselves to be, may be of interest at this point in the career of invention.

It is a well known fact that an Alexandrian named Hero, who lived more than a century before Christ, invented and operated a machine by which he secured a rotary motion from steam sent through a cylinder, and which issued through holes in the arms placed at right angles to the cylinder. This revolving, upright tube with its lateral arms was not the modern steam engine, but it was a machine made to operate by steam, and in this respect, just as much a steam machine as the

* There is nothing new only that which is forgotten.

mighty combination of pistons, cylinders, valves, and rods which drive an ocean steamer from continent to continent.

If there be anything which this age claims as its exclusive invention, it is the fire-engine. Beckmann says that the *sipho* was a machine for forcing water on a burning building, and it was in use two hundred years before Christ. He cites Pliny as having alluded to a fire-engine. "Spouting engines for the throwing of liquid fire" to a great distance were in use before the termination of the Roman civilization. It may be interesting to add at this point some recommendations which, according to Beckmann, were made by Apollodorus, "how assistance may be given when the upper part of a building is on fire, and the machine *sipho* is not to be reached." In this case, leathern bags filled with water are to be fastened to long pipes in such a manner, that by pressing the bags the water may be forced through the pipes to the place which is in flames."

Steel is not a modern invention. It is asserted that it was known to, and spoken of by writers in the Old Testament. It was used in the time of Homer. The steel in use by the ancients was not as brittle as that in use in modern times; but was nevertheless steel, and which entered into very general use. Pliny refers to soap, and says there were two kinds of it—hard and soft. A passage in Strabo permits the inference that zinc was known to the ancients; and zinc ore is mentioned by several writers such as Aristotle, Strabo, and Galen. Mirrors frequently in the Old Testament are mentioned; and there is every reason for believing that their manufacture during the height of Roman glory was carried to a very high state of perfection. The Greek artists formed on glass both raised and engraved figures; and

they knew some process by which glass could be molded like paste." * Pliny describes the method of cutting, shaping, and preparing glass; and there is reason to believe that a wheel was used by the ancient artisan as there is by the modern one; and yet it is the opinion of many that the art of glass-cutting was discovered in the seventeenth century. The hydrometer is said by some to have been the invention of Archimedes, although it is generally claimed to have been a product of some five centuries later. Tin was known to the Greeks, and so was the process known as tinning. Indigo was used by the ancients for dying, and as a medicine, centuries before its existence was known to Europeans. Gilding substances with gold was well known to the Egyptians, and is frequently referred to in the Bible. Stamp-mills for the crushing of ores were in use by the Romans, and they fully understood the processes of separating.

The citation of these few instances proves that the ancients knew many things which are supposed by many to be modern in their origin. It is already evident that the inventor and the discoverer were not idle even in these remote days; and this fact will further appear as we glance hastily over the condition of some of the more prominent of the ancient civilizations.

The enormous structures erected by the Egyptians prove that the people understood the handling of heavy weights, even to those of many tons. Roadways were constructed over long distances between the quarries, and the site of the pyramid, or other contemplated work. They must have had a knowledge of the inclined plane, of rollers, and of the lever, although some of the scores of pyramids must have been built ages before the Archimedean period. They were expert in the

* *Traite des Pierres gravés.* Mariette.

use of tools for the cutting of the hardest granite. They knew of glass and could color it in a manner which cannot be done by any of the experts of the present day — even the most ingenious of them. They could weave gold; they could spin and weave; they knew how to make the finest of linen; they had all the implements necessary to carry on the trades of woodworkers, lapidaries, and other labors connected with the guild of the artisan. "Stupendous size and mysterious symbolism," says Barnes, "characterize all of the monuments of this strange people. They built immense pyramids holding closely-hidden chambers; gigantic temples whose massive entrances, guarded by great stone statues, were approached by long avenues of colossal sphinxes; vast temple-courts, areas and halls in which were forests of carved and gaily-painted columns and lofty obelisks, towers and sitting statues which still endure, though desert winds and drifting sands have beaten upon them for thousands of years."

The Assyrian civilization was in every essential respect the peer of that of any of the others. It manufactured a superior article of bronze, and wrought it into almost every conceivable shape. The Assyrians made vases, and excelled in the making of carpets; they were at home in metal work; and in brief possessed an ingenuity in the matter of decoration, and in many other directions which is in no sense surpassed by the very best of our modern artists and artisans.

In art and learning, the Greek civilization had no rival in the other civilizations, and in many respects it is not excelled by aught that the modern world has accomplished in these directions. It has given the world much which, had it not been furnished by the Greeks, would have left our civilization far in the rear of what it is at the present day. Sculpture, and especially architecture,

owe much to Greece. Its schools of philosophy have more or less affected all subsequent thought. Its architectural results have become models from which all time has borrowed the most valuable of its characteristics. Invention was at the bottom of all this progress. It suggested models, it shaped and modeled the Corinthian and Ionic capitals; and these remain to-day in architecture as they were when the Parthenon was finished, and the Ephesian temple, opened to the world — that temple of which it was written:

> "The aspiring youth that fired the Ephesian dome,
> Outlives in fame the pious fool who reared it."

The Roman civilization was one in which conquest played a leading part; but in time, it rose to the dignity of literature, and the cultivation of the arts and sciences. It developed a high inventive faculty in the construction of roads, aqueducts, bridges, sewers and water-works. What it constructed was for all time, many of its works being yet in perfect condition. Its system of water-supply has never been excelled either in magnitude, in breadth of design, or in perfection of finish. Vast aqueducts were constructed which brought water into Rome from many miles distant, and the contents of these were taken in pipes and carried through the buildings. Eighteen centuries have affected but little many of the bridges and roads thus built; and sewers formed for use long before Christ still do duty for the Romans of to-day. The Coloseum, which seated eighty thousand people, was one of the achievements of Roman civilization, as were the wonderful baths, and the harbors, than which the world has never known anything superior of the same character.

It was during this period in ancient history, and of the existence of the civilizations under discussion, that Archimedes lived. He was to the ancients what no one

has ever since been to the world in the matter of invention. He was a mathematician as well as an inventor. Some of his mathematical works are yet in use, and prove him to have been incomparably superior to all who had preceded him. He discovered specific gravity, or the principle that a body plunged in water loses as much of its weight as an equal volume of the fluid displaced. In connection with this discovery occurred the famous incident of the crown of King Hiero. Suspecting that it had been debased by the admixture of some alloy, he referred the matter to Archimedes, who took it under consideration. One day, entering his bath when the tub was full, a quantity of the water ran over on the floor. It suddenly occurred to him that the amount of water which ran over was equal to the bulk of his body, and that by weighing the crown in water he could detect whether there was any alloy in its composition. Carried away by the conviction, he jumped from his bath, and ran through the streets in his nude condition, exclaiming: "*Eureka!*" (I have found it!)

This great inventor, who lived some three centuries B. C., is credited with about forty inventions, among which some hydraulic machines are the most noted. While on a visit to Egypt, he saw the difficulties connected with the necessities of irrigation, and invented what is known as the Archimedean screw, which is in use yet in the country in which it was invented. There is much that is probably fabulous in the accounts which have been handed down in regard to some of his alleged inventions. It is said that when the Roman fleet was attacking the town in which he was born, he set it on fire several times by the use of enormous burning-glasses; that he projected from the walls great hooks which caught the galleys of the Romans, and lifted them from the water. It was he who, in expatiating on

the power of the lever, said that if he had a fulcrum, and a place to stand on, he could move the earth. The latter assertion cannot be disputed; but supposing that he had a fulcrum, a lever sufficiently long to move the earth with his weight at the end of it, he would have to travel many millions of miles at its extremity to move the earth a single inch.

It was during this period of ancient civilizations that ships were produced which could make long voyages, and in which the Phœnicians took a leading part. The first vessel to which there is allusion in ancient history is the ark; but this was at a period long before the art of navigation had been discovered. It may be remarked, in this connection, that it is "remarkable that its proportions of length, breadth and depth are almost precisely the same as those considered by eminent architects the best for combining the elements of strength, capacity and stability." *

There is no record as to the inventor, nor is there probably any particular person, or even nation to whom the credit may be assigned for the invention of water craft. They were probably "evolved" from the hollowed log of the savage, and by slow degrees grew in the galleys of the Romans and the sailing vessels of the Phœnicians. Pliny asserts that the Thasians were the first to use full decks, which is an important step between the hollowed log and the ship which navigates the open seas. Oars and sails were both in use. It is, however, certain that the vessels used by the Romans, the Persians, and the Phœnicians were superior to those which were in use during the period known as the middle ages. The vessels in which the Anglo-Saxons invaded England were in every essential respect inferior to those

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* *Am. Cyclopædia.*

which were long in use on the Mediterranean. The means of comparison are to be found in the raising of a Roman vessel, built in the time of Trajan, which was sunk in the lake of Riccia, and which had lain there some thirteen centuries. It was built of planks of pine and cypress, according to Leo Baptista Alberta, was daubed over with Greek pitch, and caulked with linen rags; the outside was sheathed with sheet lead fastened with copper nails. On the other hand, the ships in which the Saxons invaded England, in about 450 A. D., were simply wicker work covered with skins. At the battle of Marathon, 490 B. C., the Persian force was carried over in six hundred ships, or triremes. In their third expedition against the Greeks, the Persians had over a thousand ships, and three thousand transports; all of which goes to show that the omnipresent inventor was abroad in the land.

The Hebrews also had their civilization—broken, it is true; but one which, at times, was as splendid as many of those which preceded or followed it. Some ten centuries B. C., Solomon was on the throne, the Jewish people rose to the topmost height of their power and their glory. They had won their place by an arduous struggle; they had been slaves; they had to exterminate with the sword the hostile nations who barred their progress; but now their long struggles culminated in a reign of peace. The temple was built, that wondrous structure, "the house when it was building, was built of stones made ready: so that there was neither hammer nor axe, nor any tool of iron, heard in the house when it was building."* It was a fairy structure, with its cherubims overlaid with gold, its inner court of three rows of polished stones, and beams of cedar. And then

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* 1 Kings vi., 7.

came that cunning artificer, Hiram of Tyre, a worker in brass, the son of a widow, "full of wisdom and understanding, and skill to work all work of brass." He proved a true inventor in the labor of decoration. He cast pillars in brass, and made chapiters in molten brass, and a "kind of net-work and chain-work wreathed together with wonderful effect." And he "made also a molten sea of ten cubits from brim to brim, all about . . . and a graven work, under the brim of it, compassed it, for ten cubits going about the sea; there were two rows of chamfered sculpture. And it stood upon twelve oxen . . . The laver was a handbreadth thick; and the brim thereof, was like the brim of a cup, or the leaf of a crisped lily. . . . And he made ten bases of brass, . . . and the work itself of the bases was intergraven; and there were gravings between the jointings. And between the little crowns and the ledges were lions, and oxen and cherubims; and under the lions and oxen, as it were, bands of brass hanging down. And every base had four wheels, and axletrees of brass, and at the four sides were undersetters, under the laver molten, looking one against another. And the four wheels which were at the four corners of the base were joined one to another under the base; . . . and they were such wheels as are used to be made in a chariot; and their axletrees, and spokes, and strakes, and naves were all cast."*

These elaborate details will afford somewhat of an idea of the extent to which decoration was carried in the building of the temple, and the inventive faculties required to originate all these minute particulars and to carry them into effect. Solomon had a throne of ivory overlaid with gold; and the vessels out of which

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* 1 Kings vii., 14–33.

he drank were of gold; for the furniture of his palace, as we are told, in those munificent days, "there was no silver, nor was any account made of it in the days of Solomon." Once in three years, "the king's navy went with the navy of Hiram, by sea, to Tharsis, and brought from thence gold, and silver, and elephants' teeth, and apes and peacocks." He had a thousand and four hundred chariots, and twelve thousand horsemen; in fine, the gorgeous splendors of the reign of Solomon surpass those of the most luxurious of ancient civilizations.

There were other minor civilizations in various parts of the world before the beginning of the Christian era; but there is no need that they shall be specially mentioned. In the details which have been given of the greater civilizations there is to be found enough to convince any one that one of the most active of the stimulants in their rise and progress is to be found in invention. All the civilizations of the Asiatic country had a warm love of luxury, of adornment, and architectural splendor. To gratify these tastes was the task of invention and discovery. From all that we can learn, they well performed their duty. Everything which could gratify the senses was provided. There were sculpture, wonderful buildings, splendid ornamentation, stained glass, towering monuments, monolithic works whose handling puzzles the modern observer, the finest of weapons, barges whose splendors have dazzled the ages, luxury, refinement, a lavishness of wealth without parallel, paintings, busts, bronzes, arms, equipments, everything in fact which could minister to the indolent ease and warm imaginations of oriental peoples.

The exhibition of the conspicuous part taken by invention and discovery in building up these various

civilizations cannot be doubted; but, if an active agent in building up, it would appear in the cases of these ancient civilizations, at least, to have no influence in preventing decay. Egypt flourished for two thousand years, and after having been successively conquered by the Persians, the Greeks, and the Romans, finally became a mere province with none of its ancient splendor. The Jewish development was overrun by the Assyrians, and finally extinguished by the Romans. Greece fell before the Roman eagles; Persia went down before Alexander; the Babylonian empire was hewed down by the swords of the Persians; and lastly, the great Roman civilization, in the fifth century of the Christian era, went down before the swarms of Goths, Huns and Vandals. Invention could assist, could almost create civilization, but it could not preserve it. With the fall of the Roman empire, the curtain went down on the tremendous dramas which had been enacted for nearly three thousand years, and darkness settled over the vast areas which for so many centuries contained so many grand civilizations.

One is almost tempted, in watching the rise, decline and fall of these ancient glories, to doubt that there is any such thing as permanent progress in man. It is the belief of many that the present occupants or inhabitants of some parts of America are the descendants of the powerful and cultivated race who, at some centuries or ages before, constructed the palaces whose remains are here and there found, and whose character is an assurance of a high civilization of the men who constructed and inhabited them. The Italians are the successors of the men who conquered the known world; and yet for centuries they were but a miserable counterpart of their ancestors. The present civilization largely comes from

men who for centuries have lived in debasement, and who are the lineal descendants of warriors who once were invincible; of orators, of poets, and statesmen who were second to none of their respective classes. As it were, it is the same people, with but few modifications, who rise, reach a grand development, fall, live near the earth for centuries, and then rise and fall again. In this case, human progress is simply like the movement of the waves—an uprising and a falling of the same mass. This is not progress; it is simply repetition, an oscillation, but not a movement in a forward direction.

CHAPTER III.

ACKNOWLEDGMENTS TO THE PAST.

BEFORE taking final leave of the country from which we have just been driven by Attila, Alaric, and the chief of the Vandals, it may be no more than just to give these extinct civilizations some acknowledgments of the service they have conferred on the era of modern inventions. In the last chapter, the names of a few things were given which were unmistakably the invention of the ancients; but they cover only a small part of our indebtedness. There are others which can be mentioned to advantage; and which will demonstrate that it is only the forgotten which is new.

Ballooning, not as elaborated by the French Montgolfiers, but the same in principle, was known to the ancients. It was a flying dove which is described as made of wood, and as flying "thanks to a subtile air with which its body was filled." It was but a plaything, to be sure; which, however, is about all that can be said of the balloon of the present. It has been of some service, but this has been more than counterbalanced by the damage it has inflicted in the loss of life.

The origin of the roads known as the macadam is usually attributed to a gentleman from whom the road takes its name; but the roads built by the Romans in Gaul were precisely of the kind which are now being built in France and England as macadam. The same

sort of road is in use in China, and it is charged that the so-called originator of them secured his idea of them from reading accounts of some roads which were in use among the Celestials.

Suspension bridges have been in use in China for periods long beyond the historical. The same is true of swinging bridges. The Babylonians had a tunnel under the Euphrates a score or more of centuries before the process of crossing beneath a river was in use by the moderns.

In the matter of anæsthetics, long before the Christian era, the Chinese used a preparation of the *cannabus indica* which produced insensibility. The *Bibliotheque Imperiale*, in speaking of the doings of a Chinese surgeon, says: "He gave to the sick man a preparation of *ma-yo*, and at the end of a few moments, the patient became as insensible as if he had been plunged into intoxication, or deprived of life. Then Hao-Tho made some openings, some incisions, some amputations, and cut away the cause of the illness. He applied some liniments. After a certain number of days, the invalid found himself reëstablished, without having experienced the slightest pain during the operation." The nepenthe of the Greeks is supposed to be the same thing; it is alluded to by Homer. The same thing was in use in Egypt. It is also a matter of strong proof that the ancients, and especially the Chinese, were in the habit of using iodine for the cure of goitre, and pomegranate as a vermifuge. From remote ages, the Chinese and the Japanese have employed *acupuncture* (cupping with needles) and *moxa*, the irritation of the spine with a heated iron. This is the same treatment which Charles Sumner went to Paris to receive, under the belief that it was a lately-invented French method, and which could only be properly treated in the French metropolis.

Camphor as a preventive of nausea and as a relief for intoxication, and aloes as aid to the digestion were in use among the ancients. In fact, the medical fraternity is very largely indebted to the skill of the ancients for the discovery of drugs of value and for the invention of surgical instruments, which are popularly supposed to be of recent origin. Metal probes were in use among the Romans; in the ruins of Pompeii there has been found a complete set of surgical instruments, including a catheter of bronze, a speculum, an instrument for examining the orifice of the ear, a *volsella*, a sort of pincers for readjusting fractured bones. In addition to all these, there have been found instruments for the drawing of decayed teeth; and it has also been shown that the art of replacing arms and legs was practiced—a something which has generally supposed to have been invented and practiced towards the close of the seventeenth century. *

The case of instruments in use to-day by a dentist could be replaced by instruments possessed among the ancients. Fournier is of the opinion that the filling of teeth was known by the Romans, and hints at some authority to that effect. Hydropathy is usually ascribed to Priessnitz, but it is spoken of by Horace. Suetonius is authority for the assertion that the physician of Augustus caused the death of young Marcellus by the use of the hydropathic treatment, and that this was the end of this class of medical practice. From a passage in Tertullian, some modern scientific writers have inferred that the

* "Quand on ne pouvait avec la *volsella*, remettre comme il faut les os brises, on coupait la jambe ou le bras, et on leur substituait un membre artificiel dont le mecanisme, figure sur quleque monuments, a surpris, par ses adroites articulations, nos chirurgiens les plus experts. Celui qu' inventa Du Quet, à la fin du XVII siecle, et qui lui valut de si grands éloges de la part de Fontenelle, n' etait pas plus habilament combiné.—*Le Vieux-Neue, par* Fournier.

ancients knew as much of accouchements as the most advanced experts of the present day. A verse in Lucretius gives vinegar as a remedy for the poisonous mushrooms, but the remedy was not known among the moderns till many centuries later. In the history of chemistry it is stated that the ancients knew of the virtues of mineral waters. It says that one of their remedies against dysentery was water in which a hot iron has been cooled, and is still in use.

Stoves are spoken of by Seneca, under the name of *hypocausta*; they were heated by wood, and distributed their heat equally by means of tubes carried into and through the walls. This system not only includes the modern stove, but also the modern furnace, both of which are considered to be of very late origin. Verily, there is nothing new under the sun! Allusion was made in the last chapter to veritable fire engines, which were named siphones, or sometimes the "Ctesbius machine." In regard to them, it is said by Anthony Rich, that "this pump is in reality founded on the application of the same principles in use among us." It was not till the sixteenth century that anything of the kind was introduced among modern peoples. The ancients knew how to make wood incombustible by the use of alum, than which nothing better is known to modern times. Says Fournier, in a long article on the lightning rod, and in which he cites numerous authorities, "the lightning-rod, which is to us so useful a protection, is like the greater part of things which precede, only an old invention taken from the ancients and rejuvenated by wise men for our benefit." The evidence quoted to sustain this assertion is very copious and convincing, but too long to be employed in this chapter. Suffice it that he makes out his case with great completeness.

It may be added while on this subject that in a

book known as *Sciences Occulte*, it is claimed by the author, that the use of the lightning rod was known to the ancient Jews, and that the Temple built by Solomon was protected by this agent. Flavius Josephus says that the immunity which the temple had from lightning was owing to the innumerable gilded iron points which rose above the roof. Lucretius, in *De Natura Rerum*, alludes to magnetic attraction and repulsion as exhibited in yellow amber when it is rubbed, and to which was given the name *electron*, from which we have obtained the word electricity. But nothing came of it. It was supposed to be a quality due to the form and color of the substance. It was little thought of by the observers that they stood at the very threshold of one of the most important scientific discoveries.

In an article translated from some ancient manuscripts in the possession of the French Institute, by Delecluze, there occurs the following: "Invention of Archimedes. The *architonnerre* is a machine made of fine leather which throws iron balls with a great noise and great force. They are used in this manner: the third of this machine consists of a furnace for the holding of a coal fire and the heating of water." (Here follows a description of some machinery not necessary to translate.) "At the proper moment a quantity of water is precipitated on the live bed of coals, which suddenly bursts into a vapor, and out of the tube with great violence and noise. This machine can throw a ball sixty pounds in weight." It is not probable that this is wholly reliable, for the reason that a leathern tube could not probably be of sufficient strength to resist the force of the explosion of the steam, or the sudden changing of a quantity of water into steam. However, the fact that such an invention is credited to the Greek mechanicians, and given in such detail—there even being a drawing of

the *architonnerre* in the manuscript alluded to—makes the matter one of sufficient magnitude to at least deserve mention.

The once-terrible Congreve rockets were borrowed in 1804 from a machine in use by the East Indians. There is excellent reason for concluding that the use of this agent was known to the Indians during the time of Alexander the Great. Philostratus speaks of the frightful effects produced by these engines of war, and which were supposed to be lightning which, in some manner, had been put in harness by the natives, and to act in their defence when commanded to attack an invader. Philostratus speaks of them as "torrents of fire, naked flames, charged with deadly thunderbolts, and falling on armies and devouring them." There is something in this description which suggests the idea of artillery, charged with gunpowder, and carrying destruction in their vomited flames. It is perhaps worthy of note that despite these facts as referred to by ancient writers, it is still claimed by Englishmen that they are the inventors of this deadly missile—the rocket. While speaking of the East Indians, it may be said that the discovery which is attributed to Jenner, of vaccination, or the practice of preventing or modifying a disease by the use of the virus of cow-pox, was known to the Indians centuries before it was introduced by Jenner as a novelty in the treatment of small-pox. This fact is so very interesting that it deserves more than a mere allusion.

Fournier says that, "the remedy sought during so many centuries of contagion, as a counter-poison to the terrible virus was an useless search; but all this time it was in the hands of the Hindoos, and the Persians. Dhanwantari, the Hindoo Esculapius, had spoken of it in his sacred book, the *Sactaya Grantham*, one of the

Vedas." An eminent authority* in speaking of the manner of using the vaccine, says: "The Hindoos steeped a thread in the pustule of a cow, and preserved this thread, which enabled them to be in condition to render the eruption of small-pox light in the case of all children which were presented to them. Their mode of operation was to thread a needle with the steeped thread, then to pass it in under the skin on the upper portion of the child's arm, and then the same operation was performed on the other arm, the thread being left in both places. They assert that this operation never failed to secure a light eruption; that there was but a small scab on the arm, and that there never was a case of a death among those who had undergone the operation."

The account in the sacred book referred to, the *Sactaya Grantham*, of the manner in which the vaccine matter should be taken from the cow, or from the arm of a human being who had been innoculated with the virus, and applied to the arm of the subject, is substantially the same as if it had been written after witnessing the operation of vaccination in the office of a modern physician. The pointed instrument, the puncture which mingles the virus with the blood, the symptoms following, the temporary indisposition, are all described as exactly as if the writer had taken his inspiration from witnessing a case of vaccination at the present time. In regard to innoculation, it is asserted in a *Memoire de la Condamine*, to the French Academy of Sciences, that, from time immemorial, innoculation was practiced in Circassia, Georgia, and even among the Greeks.

Many of the ideas of Adam Smith, and of other writers on political economy, are not only the same as those advanced by Aristotle and Xenophon, but they are

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* *Bibliotheque Britannique.* T. xxx., p. 134.

in almost the exact words, showing that it is not a mere accident of suggestion, but wilful piracy; socialism, and its famous maxim "property is theft," is ancient, even the motto being due to Aristophanes in his "Assemblies of Women." Asphalt was well known to various ancient nations. It was used for paving roads, streets, for building walls, towers, and the like; the famous tower of Ackerouf, near Bagdad, and built about the same time as the Tower of Babel, being constructed of blocks of this material. It is but lately that this valuable material has been discovered by the moderns, and its main use as yet is in the paving of streets. Even now, with all our genius, the asphalt which we use, is vastly inferior to that which was used by the Chaldeans. The origin of artesian wells, usually supposed to be a modern discovery, can be traced as far back as Solomon. "He cutteth rivers out of the rocks" is thought by Lenormant to be understood as referring to wells bored in the desert; and in the same way he explains the water which was produced by Moses "smiting the rock" to give water to his thirsty followers. The existence of these wells in Palmyra at a very ancient date appears to be established. "They bored in the oases some pits from 200 to 300, and even 500 aunes (about six inches) from which the water burst forth, and flowed away in every direction."*

Some Egyptian hieroglyphs show that the work of digging these wells was done by an iron tool which was raised and let fall by means of a line carried over a pulley. Window glass has been discovered at Pompeii; and now it is asserted that the glass which a Roman workingman threw down before the emperor was the modern substance known as aluminium. It has always been

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* *Olympiodorus.*

supposed that the vessel was made of glass; and as it was indented by the fall, and restored to shape by a few blows from a hammer, it is supposed that the ancients had the secret of making flexible glass. As remembered, the emperor was pleased with the exhibition, and, after he had learned that nobody had the secret of making the material save the artisan, he ordered his workshop to be razed and the man's head to be struck off, his action being influenced by the fear that a metal of the kind would be likely to depreciate the so-called precious metals—gold and silver. The modern discoverer of aluminium did not lose his workshop, or his head; on the contrary, he was the recipient of large rewards, and of no small honor from the scientific world.

A matter which has of late excited a good deal of discussion, and one of very general interest, has reference to the effects of the clearing away of forests. The conclusion has been reached that the removal of timber has the effect to increase the damage from floods by increasing their dimensions. Pliny in Lib. xxxi., recognizes this fact of the influence of forests on water, foreseeing that the suppression of the one would "lead to the unchaining of the other, and the greater frequency of inundations on account of the increasing removal of the living wood."

It will perhaps surprise the ladies to learn that crinoline is not in the catalogue of the new. One of the ancient Greek poets warns young men to "beware of women whose vestments are ballooned in the rear." To the same class will be of interest the facts that in the time of Marcus Aurelius (100 A. D.), women were in the habit of changing their hair from black to blonde; and that, according to another authority, "the women heat some irons to make curls which nature has denied them. The hair should be worn so as to fall on the forehead

nearly to the eyebrows; behind, it should float very low on the shoulders." Does not this suggest the modern "bang," and other developments of the coiffure of the present day? There is authority for asserting that in the matter of fashion of dress there has been less change; or, more strictly speaking, fashions in vogue among the ancient civilizations have been more often repeated than anything else which owes its birth to periods of antiquity.

In metallurgy, the ancients knew many processes, both chemical and mechanical, which have escaped us. Rossignal says that the ancients could handle iron in a manner which made it superior to our best steel—in a manner "concerning which we are ignorant." They could mix copper and leather, and zinc and leather. The *Britannic Review*, on the subject of the utensils of the Egyptians, refers to tempered copper, which has the elasticity of steel, and which was not liable to oxydation. Castellani, an eminent authority on the subject concerning which he speaks, says: "The ancients had some chemical processes of which we are ignorant, for fixing the sinuosities of small granulations which run in borders on the greater part of Etruscan jewelry. In fact, despite all our efforts we have not been able to reach to the reproduction of certain works of an exquisite fineness to which we despair of attaining unless there shall be some new discoveries in science." Said a great artist to Clement VII., when showing him a collar of gold found in an Etruscan hypogeum, "Alas! it is better for us to seek a new way, than attempt to equal the Etruscans on their own ground in the working of metals. To undertake to rival them would be a certain method of demonstrating that we are simply wretched copyists."

The enumeration of the various articles which are believed to be modern, but which were known to the

ancient civilizations, might be continued through a volume. There are scores or hundreds of results in chemistry, supposed to be of late origin, but which were known twenty or thirty centuries ago. There were some forty mechanical inventions given to the world by Archimedes, and a rather larger number by Aristotle, nearly all of which are in use now, either in their original form, or after having undergone some modifications. That there would have been even more discoveries made by the ancients is probable, were it not that among the thinking men of that age, and more especially among the Greeks and Romans, anything of a mechanical nature was considered a degradation. Mechanical inventions were thought by Archimedes to be unworthy a philosopher, so that what he gave to the world, he regarded, or affected to regard, as mere playthings.

When it is known how very extensive were the appliances of the ancients in the shape of inventions, there is less difficulty in accounting for the high order of civilization which they attained. But this element did not prevent their fall. What were the causes which undermined these ancient civilizations is not an *apropos* consideration in this work; but without referring to anything in the nature of causation, it may be remarked, that some good purpose was intended, as in the case of the geological development of the world, the waving forests grew to luxurious beauty, fell, and were again and again renewed to constitute the fuel which is now one of the main factors in the modern world's development. It may be that the rise, the growth, the fall of the successive civilizations is the slow process of forming a stratum which, in the moral and mental geology of the future, will play an essential part. The various accretions of the ages have their purpose; the dead of to-day form the foundation, and the nutrition of more

valuable growths of to-morrow. Somewhere in the coming time the value of the work done by the ancient civilizations, and the benefits conferred by their death will be recognized. It will be seen that they were forming a stratum without which the progress of man would be impossible.

There were seeds sown centuries ago in Egypt, China, Assyria, Judea, Greek, Rome, and the other centres of exceptional development, which are already bearing fruits. We owe to them very much in the matter of suggestions in law, in morals, and in government; and what we have thus gathered is but the first fruits of the harvest. As the mighty past is more and more developed under the pick and shovel of a Schliemann; and the hieroglyphics of Assyria, Egypt, Central America, and other portions of the ancient world, become readable under the keen eyes of the Champollions, we shall find that every element in the past had a beneficial use intended for advantage of the future.

CHAPTER IV.

THE "DARK AGES."

THERE have been numerous sub-divisions of the period during which man has occupied the earth. There were four given by Ovid, five by Hesiod; Fichte mentions five, while Hegel and Compte decided on three, the last being the one in which we live. However, the generally accepted division consists of three: the first being the ancient; the second, the Middle, or Dark Ages; and the third the modern age. The middle or dark ages are generally agreed upon as extending from the fall of the western empire to the discovery of America by Columbus.

"The dark ages is a term applied in its widest sense to that period of intellectual depression in the history of Europe from the establishment of the barbarian supremacy in the fifth century to the revival of learning about the beginning of the fifteenth, thus nearly corresponding in extent with the middle ages. The last of the ancient authors was Boethius, after whose death, in about 524, the decline of literature, prepared during several previous centuries, became inconceivably rapid. The darkest period for Europe generally was about the seventh century. The earliest sign of revival, however, was seen in Ireland as far back as the sixth century. In the tenth, England and Italy were in a deplorable condition of barbarism, while in France and Germany there was more

or less culture, which increased considerably during the eleventh. The comparative prosperity of scholastic learning in the eleventh and twelfth centuries was followed by a relapse in taste and classical knowledge which lasted through the twelfth and fourteenth." *

This is a definition which very fairly covers the period referred to. The debasement of these centuries does not, however, apply to every phase of human development. It is true that learning was at its ebb; the masses were ignorant and brutal beyond conception; morals were at a grade too low for measurement. Society was composed of a mixture of barbarism, ignorance and gross superstition. Might made right. The feudal system prevailed during a portion of the period; and feudalism, although having many admirable traits, was, in the main, organizations of various bands of robbers led by different chiefs. They were permitted to carry on their profession of rapine and murder subject only to a head, called a king, or emperor, as the case might be, and who himself differed from his subordinates in being a robber on a more colossal scale. They robbed each other; he robbed provinces, states, kingdoms according as they were weak and unable to defend their own.

Learning disappeared, but a certain amount of growth was exhibited in other directions. Painting grew to be an art whose practical development in the opinion of many has never since been equaled. A good deal, too, was accomplished in the direction of architectural results, in which the Gothic is a conspicuous example. Some advance was made in some portions of Europe, in certain directions, which are worth a hasty glance.

To a certain extent, the Byzantine empire, with its capital at Constantinople, preserved what little light

* *Am. Cyclopædia*, vol. i., p. 186.

there was amidst the Cimmerian gloom that spread over every part of Europe save for a few centuries in Spain. It preserved a certain amount of civilization, and it was the custodian of such letters as there were to be cared for. The history of this empire is most interesting, and it fails to receive the recognition which it deserves at the hands of posterity. Anything more than a mere allusion to it does not come within the scope of this work, as it did not, to any perceptible extent, add to the arts or inventions during its existence. It lived some eight centuries, and was extinguished by the Moslem, whose descendants now possess it.

Far more interesting is the history presented by the Moors during their eight hundred years occupation of Spain. Modern Anglo-Saxon writers seem chary of acknowledging the indebtedness of modern civilization to the Hispano-Moors, fearing, perhaps, that their race will be shorn of some of its glory if it be shown in any instance that they are not the authors of all the great improvements of the modern peoples. However this may be, there is most excellent reason for concluding that, had not the Moors been in occupancy of Spain, our present civilization would be retarded for indefinite centuries. The Arab wave that swept over Spain in the seventh century seemed at the outset a damaging inundation, but it left, when it receded, deposits which have made fertile the otherwise unfruitful fields of western and central Europe. The influence of the Moorish occupation on the literature of considerable portions of Europe is very great. "It can be traced in the reproduction of many of the stories as well as in the structure of the French metrical tales. . . . It extended into Italy, and is found in the charming stanzas of Ariosto, both as to matter and manner, and in 'twice-told tales' of Boccaccio's *Decameron*. In a word, the entire southern literature of

Europe, up to the Renaissance, owes as much to the Spanish Arabians for matter and form, as it does to the Latin for language." *

But it is in the matter of arts and inventions, that the indebtedness is very great. In no particular instance did these people prove themselves original in the matter of invention, but they utilized, and put in circulation that which they had learned in the far east, more especially in China and in India. That they brought gunpowder into Europe is not disputed by the more intelligent; they did not claim to have discovered it, but simply to have brought it to Europe from China, where it had been in use, within a limited area—as to purposes—for several thousand years. Amiot, a missionary to China, says that it was known some three centuries B. C., and gives the ingredients as being sulphur, saltpetre, and charcoal. There is a manuscript of oriental origin, extracts from which are given in the *Journal de l' Institute Historique*, in which it is declared "that gunpowder came from China to Persia, thence to Arabia. Thence it was taken into Spain." It is asserted to have been used by the Arabs at the siege of Mecca, in the year 690, or some six hundred and forty years before its first recorded use by the Europeans at the battle of Crecy.

Concerning the much-disputed priority for the invention of printing on movable blocks, the historians of the Spanish-Moors are not at all backward in asserting that they played a most important part in giving the world this, the greatest invention of the ages. They do not claim that the Moors were the inventors of movable types; but they do insist that it was they who brought paper into Europe, and that, without paper, printing would have been of no practicable value. "It has not

* *Conquest of Spain*. Coppée. Vol. ii., p. 353.

been sufficiently noticed," says Coppée, "that what retarded the printing-press, and greatly restricted its usefulness, when it appeared, was the want of paper. It was not so much the stolidity of man that kept the art back so long, as the cloth, the papyrus leaf, the sheepskin called *pergamina*, or parchment, and the calf-skin called *vellum*." The Arabians had gotten from the Chinese a paper made from silk, and catching a hint from it, proceeded to manufacture paper from cotton at Mecca, in the eighth century. This method was introduced into Spain, and in place of cotton, flax was substituted. Hallam says that the "Saracens of the Peninsula were acquainted with that species of paper made *ex rasuris veterum pannorum*,"—which means the rags of old clothes. So soon as paper became known, the printing-press became of value; but up to that time it was almost as valueless as a cannon without any gunpowder. From this point of view, it will be admitted that the Spanish-Moors are entitled to a large share of the colossal results which have been achieved by the invention of the art of printing with movable types.

The magnet and the needle are asserted by Coppée to have been known by the Moors in Spain, they having discovered them among some of their eastern conquests. They made no use of their knowledge for the reason that their sea voyages were limited to "short trips in the Mediterranean from headland to headland, which did not require the use of the compass; and therefore the invention languished because no imperious necessity called for its application."

"Before the twelfth century," says Gibbon, "the secret of silk-manufacture had been stolen by the dexterity and diligence of the Arabs. The khaliffs of the east and the west scorned to borrow from the unbelievers their furniture and their apparel, and two cities of Spain, Almeria

and Lisbon, were famous for the manufacture, the use, and perhaps the exportation of silk. The Moors were noted for their Damascus sword-blades, which they had probably discovered in the city of that name; and they manufactured also the Toledo blade, whose reputation extended all over Europe. They manufactured a very superior leather known as Cordovan, taking its name from Cordova, and which now appears under the name of Morocco, from the place in which it is made."

Europe and the world owe much to the Moors for novelties which have not been enumerated in this brief outline. Their civilization was a bright one, and the Moors themselves were in the nature of a feeder which ran around the first centuries, and which, beginning in China, Egypt, and other portions of the East, emptied into the close of the dark ages, and furnished much of the material of the new civilization. The great river of human progress had been dammed in middle and southern Europe until it had become a stagnant lake—motionless, dead, tideless. From China and Egypt, the Arabs cut a canal which ran by way of Arabia, the Mediterranean, through Spain, and was finally emptied into the hither end of this stagnant basin. This current was reinforced by the streams which began to flow from every direction, until it became the grand river which bears on its bosom the glittering burden, the precious freight of modern civilization.

And the great stagnant lake remains dead even unto this day. Its bottom is lined with the skeletons of strangled thoughts. In the ooze and slime of its vast basin are the bones of a slaughtered civilization. It is a receptacle filled with the bodies of those who attempted to work for human advancement, who believed that right should dominate might, that free thought was man's birthright. Here are the corpses of the hundreds

of thousands who gave their lives for the sake of rescuing a sepulchre—which they did not rescue.

This great basin in central and southern Europe filled with the dead waters, and crowded with the corpses of those who struggled for the right to think for themselves, is the blackest spot known to human history. Like the cave in which dwelt the fabulous Cimmerii, it is covered with eternal darkness.

Invention had but little to do with the earlier portion of the period known as the dark ages. Some advance in furniture was made in the seventh century. Something was done for ceramics in the eleventh century, and about this time, there were made some valuable tapestries, more especially the famous Bayeux, supposed to be largely the work of Matilda, the wife of William the Conqueror. There was some creditable gold and silver work done; but the main advance, until very late in the ages, was in the character of arms and armor. Great results were achieved in the days when it was the custom of the titled warrior to envelop himself in a case of steel, and then with lance in rest to charge on the footmen who, unprotected by armor, were bowled down like ten-pins by the the steel-clad knights. But a gallant show was it that was made in the days of chivalry, as the armored hosts rode out on their cuirassed chargers to rescue the sepulchre from the infidel, to rob a neighboring chief, to seek for opportunities to rescue imperilled "damosels!" Their burnished armor, their champing steeds, their clanking arms, the masses of waving plumes must have been a glorious thing to see and hear—so glorious that it even gave a certain sort of dignity to murder, to robbery, to the gross superstitions for which they so freely gave their lives. As may be expected, the main improvement which this element indulged in was the invention of new kinds of armor, and in this direction, they

displayed a taste and an ingenuity which, if directed into channels for the benefit, instead of the killing, of mankind, might have saved a portion of the dark ages from the infamy which envelops them.

The early part of the dark ages did nothing that is worth recalling. Towards the close, something was done in watches, playing cards were introduced, the art of frescoing was revived, as practiced by the ancients, architecture began to exhibit signs of life. Something was thought of in the shape of book-binding, although there were few books to bind. Byzantine styles began to be succeeded by the Norman, the Gothic made an appearance, and the continent assumed somewhat less than before, the appearance of being a country in which a few of the people occupied palaces, and the vast majority, pens like swine.

There is some little compensation in the last portion of the middle ages for all the damage they had inflicted on the cause of humanity. Some painters on wood and canvas grew into existence, and their works have preserved their memories to this day, and will continue to preserve them when another century or two shall have rolled away. Such men were born as Leonardo da Vinci, Michael Angelo, Perugino, Raphael, Titians, Tintoretto, Veronese, Correggio, Parmigiano, Albert Dürer, Guido, Holbein, and many others who, for the first time in the history of art, attempted to represent nature in art, and to present to the world the figures, the events, the scenes of Christianity, not through some mystic representation, but as they actually presented themselves to the living observer. The Mater Doloroso, the bleeding and thorn-crowned head of the Christ, the awful agonies of the crucifixion, the dying sufferings of the saints, these were the subjects brought in by the different schools, and given with all the realism possible to

ardent imaginations imbued with a desire to make the most of their faith and its sufferings and its benignant acts and promises.

Finally there came Luther. Printing was discovered. Columbus ran the prows of his little fleet against the immovable shores of a new world. Gunpowder was in use—the mariner's compass was a fact. The curtain which had fallen on the nations when the barbarians swarmed over the sacred city again rose on a new act in the drama of Human Progress. Invention, which had been terrorized into inaction by the vision of the stake, the thumb-screws, and the rack, was liberated as to thought, and at once it sprang forward to aid in building up and developing the new and latest civilization.

CHAPTER V.

GUNPOWDER; OR, THE NEW BIRTH OF INVENTION.

THE world has never done justice to the part which gunpowder has played in the awakening and the establishing of our modern civilization. Perhaps had not this explosive made its appearance, at this very moment, when steamers are ploughing across the ocean, and railway trains are threading their way across almost every township in Europe and America, and the smoke of factories everywhere obscures the sun, the world would have been where it was ten centuries ago; armored squadrons of knights would have been charging with lance in rest on the serried ranks of unarmed footmen, and the great sport of killing in which the killer could not be killed, and the victim could not avoid his fate, would still be in progress. But gunpowder came along after the titled had had a few centuries of sport—of enjoyment of the *battue*, of a healthy chase like unto that of pig-sticking, with men for pigs—and changed all that. Gunpowder is the democrat of inventions. It is no respecter of persons; it is the great leveler. A pigmy, with a small quantity of this leveling mixture, nicely packed behind a diminutive piece of lead, and the whole enclosed in an iron tube which could be carried on the shoulder, or even in the pocket; this pigmy, base-born perhaps, a herder of swine it may be, not the friend of any "lady fair," or desirous of being

crowned by the queen of beauty; nothing of the kind, in fact; yet this base-born churl who could not lift a battle-axe, and possibly did not know a lance from a lamp-post, was the equal, the superior, in fact, of the proudest knights that, clad in full armor, ever rode a champing steed to battle.

Gunpowder ended all the cruelty, the inequality, the braggadocio of knighthood. It made fighting as dangerous for the knight as for the unprotected wretch whom he used to spear, hack, and brain in his charges. Armor came off, lances were placed in rest in a manner different from that when unsteeled breasts were the targets aimed at; the battle-axes, and breast-plates, the greaves and the helmets were hung upon the walls to be taken down no more forever.

Who knows, too, what effect this dark-looking mixture may have had on the arrogance of the spiritual and temporal heads that dominated through the dark ages, both holding the lives and the fortunes of their subjects at the disposal of their will? Who knows what influence saltpetre may have had in securing the concession of Magna Charta, in enforcing the demands of the people that they had the right to think, and that they were not by mere accident of birth the slaves, the chattels of the men who had claimed to own them from time immemorial? Undoubtedly the dominant classes of that day thought:

> "It was a great pity, so it was,
> That villainous saltpetre should be digged
> Out of the bowels of the harmless earth,
> Which many a good, tall fellow had destroyed
> So cowardly; and but for these vile guns
> He would himself have been a soldier."

The explosive qualities of gunpowder are often put in use to remove obstacles which occupy sites intended for an improvement. So, on its introduction, and its use in

Europe. There was a new civilization contemplated. The site on which it was proposed to erect it was encumbered with all sorts of natural and artificial impediments. Gunpowder was applied to them, and they were blown into fragments. The ground was cleared of the encumbering, unsightly, centuries-old obstacles. The site was now in readiness for the materials and the builders of the new civilization.

That which has done so much for the good of mankind deserves some special mention. There are dozens of claims as to the men who invented it, and the period, the nation in which gunpowder was first known. The popular belief ascribes its invention to a monk named Swartz; and to Roger Bacon. There is no probability that either of these is the inventor. A chronological statement has been compiled by Rziha, as follows:

In the year 80 A. D., the Chinese are credited with possessing a knowledge which they had obtained from India. In the year 215, according to Meyer, Julius Africanus described its preparation. In 668, Callinicus of Heliopolis introduced Greek fire to the Byzantines, which was probably gunpowder, and was used to project stone balls from "pipes." In 690, the Arabians employed fire-arms against Mecca, having gotten the knowledge of gunpowder from India. In 811, the emperor Leo employed fire-arms. In 846, Marcus Gracchus described the composition of gunpowder. In 880, Leo, the philosopher, made rockets for the army of the eastern empire.

In 1073, King Solomon of Hungary bombarded Belgrade with a cannon. In 1085, in a naval battle near Toledo, the ships of Tunis "shot fiery thunder." In 1098, the Greeks used artillery against the Pisans. In 1232, the Tartars employed "fire-pipes" against the Chinese. In 1228, Don Jaime threw into Valencia fiery balls, which burst. In 1247, Seville was bombarded with

artillery. In 1249, Damietta was defended against St. Louis with bombs, which on this and other occasions were much dreaded by the Crusaders. In 1280, there died at Cologne, Albertus Magnus, a preaching monk, said by some ancient writers to have invented "*Bombardum, bombardulam et scolpum manualum.*" In 1294, Roger Bacon died, in whose works the destructive qualities of saltpetre, and the production of terrible thunder and lightning from its compounds, are alluded to, as is well known. On a cannon, now in an arsenal in Batavia, is the date 1303. In 1311, Henry VII. bombarded Brescia with "thunder-guns." In 1312, the Arabs had cannon before Baza. In 1326, Martos was attacked with artillery. In 1330, Berthold Swartz is said to have discovered gunpowder. Other authors place the date at 1320, 1354, and 1380. *

It has often been asserted that the first use of gunpowder was at the battle of Crecy, in 1346; but there are authorities for its use at a much earlier date. In 1334, Petrarch elaborates on the terrible character of the new powder and cannon, which, as he states, were then very largely in use. Among the battles in which artillery and gunpowder were employed, as stated by various authorities, were those of Alicante, in 1331; at Pui Guillame, in 1338; at Salado, in 1340; at Algeciras, in 1342; and at Crecy, in 1346. In the latter part of the same century, the English had four hundred cannon in position before St. Malo. At the close of the fourteenth and the beginning of the fifteenth, powder came into very general use. England imported it until about the middle of the sixteenth century, and then commenced its own manufacture.

Since that period gunpowder has been used for an

* *Am. Cyclopædia.*

interminable number of purposes, of which, however, war has claimed no inconsiderable portion. It has been employed for hurling projectiles, for blowing up mines under fortifications, for the manufacture of innumerable forms of fire-works. At first, in accord with the spirit of the age during which it came in use, it was harnessed to the car of Mars, and forced to assist in the great game of slaughter in which the world at that time was mainly engaged. The outflash of its flames was seen over Europe for centuries; the hurtling of its missiles, and the crash of its exploding shells were the music which saluted the ears of the armies engaged in their mission of encroachment or defence.

In this labor, there is no doubt that gunpowder was an evangelist, a missionary whose general average of results was beneficial. The centuries immediately succeeding the dark ages needed something with the energy of the new invention to disrupt them; to rend their cohesive ignorance. There was gold to be had in the lodes of these centuries, but it was deep-buried in the solid granite which had formed during the epoch which had preceded them. Something which embodied tremendous energy was imperative in order to open these veins, to tear apart their encrustations, to grind them to powder, and thus render them susceptible to the moral processes of separation. Hundreds of thousands were killed, but many of them deserved it; others were in the way of the approaching civilization, and their removal was essential. Upon the whole, the cannoneers of that period did the world no mean service. Castles which had been the refuge of powerful assassins, whose dungeons had been the living tomb of myriads of the weak, were leveled to the ground. Murder, rapine, oppression became less demonstrative as they found that stone walls could no longer preserve from the vengeance of the masses.

There was in all this killing which followed the advent of gunpowder, a general tendency in the direction of the right. There were instances in which simple might triumphed over right, but the average of the results accomplished was in the interests of man.

The value of gunpowder as an assistant of the industries of the world has been incalculable. Without it many of the grandest railway routes of the world would not only not have been built, but even unthought of. It rendered possible the Hoosac and Mont Cenis tunnels; it has opened rivers to navigation and rendered new areas accessible, and thereby populous, fertile, and valuable. It has opened new harbors, has made possible railways across the Rocky Mountains and the Sierras; it has excavated wells without which vast areas would be uninhabitable; it has rent the marbles from which come sculptured forms; it has furnished the blocks of stone for the construction of cities, churches, and palaces; but above all has it been of inconceivable value in the assistance which it has given the miner. The auriferous and argentiferous mines of the world would be, in the main, unknown had it not been for the inventive genuis which gave us gunpowder. Millions and millions and still more millions have been added to the values possessed by mankind from the aid of this obedient but most potent agent.

It has greatly blunted in the popular estimate the value of personal hugeness. Once there was a time when a man's value was measured by the extent of his muscles, the height of his figure, and the potency of his arm. This was in the brute age — an age that once dominated the world, and which even yet is not extinct. The weak were everywhere the prey of the strong. Nations cultivated men of muscle, and size, as they encourage the breed of certain cattle. Physical strength

was valued above mental vigor. In that brute age, men could neither read nor write; they did not need to. If they could wield a sword so as to cleave a man from scalp to chin, and could swing a ponderous battle-axe, their career was assured. They needed no learning save to despise the common people, and to hew and bruise, and kill. Gunpowder came, and soon everywhere the stature of mankind rose to the elevation of the tallest. With finger on trigger, and eye sighting along a slender tube, the smallest of men became of the height of the largest. One thus prepared was the peer of the kingly *Cœur de Lion*, whose mighty battle-axe was a load for a horse.

Socially, morally, and in an industrial sense, the invention is immeasurably invaluable. It has brought up the stature of the small of the world until all are of a height. It has changed the contempt of the powerful for the weak, if not to regard, at least, then, to a wholesome respect. It has been the great leveller of modern ages. It has swept down dynasties, "divinely" established and endowed, and brought the people from the vilenesss and degradation of serfdom to a position where they are listened to, respected, and where they have established the formula that their "voice is the voice of God."

It is curious to note the increase in industries which the invention of gunpowder created and which relate solely to arms for warlike and sporting purposes. Today there are but few branches of manufactures which are more important, in the amount involved, operatives employed, and results attained, than is that one which has the construction of arms as its specialty. The cannon which were first used after the introduction of gunpowder were a species of mortar, shaped like the mortar of an apothecary, and were known as bombards, and threw

balls of stone. The progress of the bombard from its original form to its final result was a long one. It was at first made of bars of iron hooped together like a barrel; it was next made of wrought iron, and then of bronze, and finally of steel. The culverin was the successor of the bombard, and was shaped substantially like the modern cannon. Some of them were of enormous length, one of which was not less than twenty-five feet, and may be seen at Dover, and concerning which the piece itself is pleased to say: "Sponge me out and keep me clean, and I'll send a ball to Calais green!" As the ball which it would carry weighs only twenty-five pounds, it would not do a very great amount of damage, even should the promise of the gun be carried into effect. In the fifteenth century shells were introduced, and from that time to the present, all sorts of improvements have been made. The difference between an ancient culverin, throwing a small stone, and the hundred-ton gun of Armstrong, with its breech-loading apparatus, and its elongated missile of nearly a ton in weight, and with an effective range of several miles, is a difference which is fairly characteristic of the peculiarities of the two periods in which they appear. The change in small arms is equally marked. The first fire-arm was a simple tube supported by a stick, and braced against the shoulder, and fired with a coal. From this primitive weapon came the arquebuss, which was fired by the wheel-lock, then the flint-lock, then the percussion-lock, with cap and nipple, and finally the modern gun with its metallic cartridge, its elongated bullet, and its wonderful precision.

The amount of capital employed in the manufacture of material brought into use by the invention of gunpowder is simply stupendous. Every country has its arsenals for the making of cannon and small arms. The

Krupps occupy acres of ground, and employ thousands of operatives in the making of steel cannon alone. Woolwich, in England, is a vast enclosure devoted to the manufacture of the monster eighty-ton cannon, and other guns, and articles needed in the operations of war. The small-arms manufactories all over the civilized world are hives of industry; some of them are run by the governments, and others by private capital. The Winchester company in this country, and the Remingtons, send their guns to all parts of the world, civilized and uncivilized. In the war between Russia and the Turks, the latter were supplied with American guns, whose value is attested by the cost of the resistance to the invader. The manufacture of arms is a curious art, which forms no part of this article on gunpowder, save as it serves to illustrate the value of the industries which have been fostered into existence by the invention of this explosive. It is an evidence of what a single branch of invention has done for the world in the stimulation of industries, and the expansion of human energy.

In the manufacture of gunpowder, there have been many advances. The Berthold Swartz, who is by many given the credit of the invention of gunpowder, is thought by good authorities to be the inventor of granulation. The powder now in use is substantially the same as that in use at the outset; but there have been improvements in the processes of manufacture. There are different methods of granulation, different as to the size of the grains, and also as to their shape. The branch of industry created in this direction is by no means a small one. There are factories for its making to be found in every country, although latterly, for mining and similar purposes, a much better substance has been found in nitro-glycerine, and in dynamite, although

neither is in any respect of a nature that will permit its being used in cannon or small arms.

This is all that needs be said of the invention and the value of gunpowder. It may be asked very naturally why it did not make its appearance before, if so long known to the inhabitants of China and India? One reason is that the world was not ready for it; that is, that part of the world which was destined to become the foundations of this modern civilization. From 1150, the date of the discovery of the mariner's compass, to the Reformation in 1517, there were some centuries which had a special use. They were the threshold of the new civilization. It was necessary that they should be eventful ones, crowded with incidents which should shock the sleeping powers of Western Europe, and awake the nations from the lethargy in which they had been so long plunged. The mariner's compass, gunpowder, printing, the discovery of America, and, later, the telescope, were the agencies that were developed at this crisis. Gunpowder, so to speak, jarred the nations, upturned and overthrew existing things, and resolved institutions, forms, orders, and the like, into their original elements. Many things were effaced, others obliterated, the hurtful crystallizations in social, religious, political and other directions, were dissolved into elements capable of reconstruction in other and better forms. Then came printing, which diffused somewhat of intelligence through these disintegrated elements, and which began to act as a bond of union, to form new crystallizations, to cement new accretions, all of which were congenial and possessed of potent affinities, and which were to become the material of which the new order of things was to be composed. Gunpowder could have come sooner, if it had been needed; and so could printing. The latter was known for a long period before it was needed in the

projected genesis; but it assumed shape when its services were most in demand. Had the order of the coming of these two been reversed there is no reason for thinking that mankind would have made as rapid progress, or that it would have made any at all so as it might be influenced by these agencies. The Reformation, before the use of movable types, and the printing press, would have been no reformation, but an effort which would have fallen lifeless on the public, and would have been speedily ended by the removal of its author.

What agencies are at work to adjust such appliances as these to the necessities of man so that they come only at the opportune moment needs not be examined here. Experience will bear out the assertion that occasion creates the instrument. The world has had thousands of unknown Alexanders and Napoleons; and the reason that they remained obscure, and never conquered worlds, was that there were no worlds to conquer. Had the Macedonian lived a century earlier, or later, than he did, he would never have been heard of, but there would have been some other one, with all his masterly genius, to take his place.

CHAPTER VI.

PRINTING; OR, THE "ART PRESERVATIVE OF ARTS."

AS in many other cases, the world is indebted to the despised Chinese for its first knowledge of printing; not printing as now practiced with movable types, but printing in which an impression of the types is taken on paper. So far as can be ascertained, the Chinese were in the habit of printing from types as early as the commencement of the dark ages. In their method, the matter to be printed was first written on a sheet of paper, and then laid on a flat surface of some species of hard wood. The characters of the paper being damp, left their impression on wood; then all of the surface was dug out excepting the marks which had been left by the inked paper, with the result that the surface of the wood left a perfect *fac simile* of the characters. These were then inked, a clean piece of paper was laid over the block, and either pressed down by some weight, or rubbed with a brush, as is now done in printing offices in taking a "proof" of an article in type. By this slow process, the Chinese carried on printing with entire success, and produced a large number of works—all of their manuscripts which contained the literature of former ages being reproduced in book form with printed contents.

Before movable types were discovered, printing according to the Chinese method was in use in Japan; also in Italy, Spain and Sicily, but mainly for figures on silk

and cotton stuffs. It was also used for producing the various figures on playing cards. In the early part of the fifteenth century, there were books produced by the block process, a religious book known as the *Biblia Pauperum* being the most celebrated, and which bears date of the earlier part of the fifteenth century.

As said in another place, there was no necessity for any improvement in the art of printing until there should be a supply of paper, and this was furnished by the Hispano-Moors at about the beginning of the century in which movable types were invented. The supply of paper furnished the opportunity for an increase in the rapidity of printing, and then the improvement came. The most that can be said of what very soon followed is that printing was not invented, but improved; so much improved, however, that it scarcely in its improved form bore any resemblance to its olden self.

The improvement referred to, or what is generally known as the invention of printing, consisted in the discovery that if each letter was made by itself, it could be used again and again as occasion required. This is all the difference in theory there is between printing as practiced to-day and printing as practiced by the Chinese inventors. The difference, however, is one of the greatest importance; it is the difference between the speed of a train drawn by a locomotive, and a cart drawn by a yoke of oxen. The one required only the letters of the alphabet, which could be used until worn out; and used for a thousand different articles without reference to the subject. The other demanded new letters in every change of page, for every new article, and which had to be thrown away when any work was completed. Something analagous to the cost of block printing can be fancied, if one will suppose that the type for each page of a newspaper had to be cut out on a block each day, and

that the page of type, when used should be useless, and have to be destroyed. There would be no such thing as a newspaper if this were the method. It would take weeks to produce the page, and the immediate destruction of a page after being used would involve an expense which would make a single issue of an average newspaper cost a fortune. There would be no newspapers, no books for general use. The printing of a book would require years of labor, and would be so costly when finished, that only corporations, or men of the greatest wealth, could afford to purchase one of them. In fact, without the invention of movable types, the world, so far as any benefit it may have received from printing is concerned, would be just where it was at the beginning of the fifteenth century. The invention of printing is entitled to credit; but it is to an invention in the improvement of printing that the world owes its gratitude.

Despite the nearness—comparatively—of the invention of movable type, there is some doubt as to the name of the inventor. It is generally credited to Johann Gutenberg, of Metz; but there other claimants who have their adherents. The Dutch ascribe the invention to Laurens Coster, of Haarlem, asserting that he was the inventor, and that it was stolen by an employé named Gutenberg. In 1823, the Dutch celebrated the fourth centennial of the invention of movable types by Coster, and erected a monument to his memory. The other claimants are Johann Faust, of Mentz, and his son-in-law, Peter Schöffer. It is, however, the general opinion that Gutenberg is the one entitled to the honor, that is to say, the general opinion among the Anglo-Saxon, and the German peoples.

There has been a claim that the Romans knew something of movable types; but there is no adequate proof of the truth of the assertion; and even if it were the

case, it cuts no figure, and detracts nothing from the honor due the modern inventor. "Printing should rather be considered as the result of general causes on which the progress of society depends, than as the simple outcome of a happy hazard." * Printing came when the world had need of it, when it could have value. It came in about 1440; in season for the grand events about to be unfolded. It had no relation to the present. The great mass of the people could not read; and if they had been able to read, there was nothing to print that would have been of value. The monasteries were in possession of many of the ancient manuscripts, but they contained nothing which was of interest to the masses. It might have been of some use in distributing the official papers of the higher religious authorities to their subordinates; there might, and probably would have been found for it, certain clerical uses, but nothing which would reach the body of the people. A little more than half a century later, Columbus was to discover the western continent; in three-quarters of a century, the Reformation was to make its appearance, and then there would be a use for the printing-press. The masses would begin to think, and when this should be the case, they would need books.

It cannot be said that printing led to the great Reformation, for the reason that it had not done anything to reach the people and render possible thought of reform. The period was one in which destiny was gathering its forces for the renaissance of the race. Gunpowder was one of the agencies; the printing-press came next, and fell into line; the discovery of America was another of the agencies, and the Reformation was still another, and of all, not the least potent.

* Dugald Stewart.

To "an obscure mechanic" the world owes the "art preservative of arts." In speaking of the origin of writing, Lamartine says: "It is not known who invented writing; all that which is almost divine is anonymous." Knowing that Gutenberg's name is prominent in connection with printing, he adds that this "obscure mechanic did not employ his invention as do ordinary inventors; no, he employed it through piety, through a holy endeavor to secure a certain end." The same writer quotes Gutenberg as having written in these pious words: "God suffers because there are such multitudes of souls to whom His sacred word cannot be given; religious truth is captive in a small number of little manuscripts, which guard the common treasures instead of expanding them. Let us break the seal which binds these holy things; let us give wings to truth that it may fly with the Word, no longer prepared at vast expense, but multiplied everlastingly by a machine which never wearies—to every soul which enters life!"

Gutenberg was born at Metz, or Mayence, one of the free and wealthy cities on the Rhine, in the year 1400. His father's name was Friele Gensfleich, his mother's Elsie Gutenberg. He was a second son, and took the combined name of his parents, Johann Gensfleich Gutenberg. Mingling in some intestine quarrels he was banished; he returned, and soon after he was again banished at the age of nineteen years. He went to Strasburg, where he remained ten years in study; he was invited to return to Mayence and refused, whereupon he was proscribed as a public enemy, and in the meantime received concealed aid from his mother. His popularity in Strasburg was so great that, on an occasion when the chief magistrate of Mayence passed near the city, he was seized, imprisoned in a chateau, and was only released when he signed an agreement to give to Gutenberg

JOHN GUTENBERG.

(From a print in the National Library at Paris.)

(p. 81)

his confiscated patrimony. With his wealth in his possession, he was able to study and travel, during which he visited men of science, artisans and artists.

"It was at the epoch," says Lamartine, "in which the trades, then scarcely known, were confounded with the arts. . . . The artisans then held in Germany the same rank as the artists. He traveled alone, the valise containing his clothing and his books on his back, like a simple student visiting the schools, or as an artisan in search of a master." He traveled though several of the states of Central Europe, and, according to an authority, filled with one thought: "how to expand the Word of God among a greater number of souls."

It is said that when in Haarlem, Holland, he one day met Laurens Coster, the sacristan of the cathedral, and formed for him a curious but strong attachment. During their intimacy, Coster one day exhibited to him a Latin grammar which had been produced on a wooden plank for the instruction of the students. It is related of Coster that he was in love, and, one day, when taking a walk, he seated himself under the willows on the banks of the canal. His heart was filled with the image of his beloved, and with his knife he attempted to trace out a monogram in which should appear the first letter of his own name and that of the woman he loved. In place of cutting the letters on the bark of the tree, where they could be seen, he took small pieces of willow, stripped off their bark, yet dripping with the sap of spring, and then kept them as a souvenir of his dreams of one whom he loved. One day, having thus cut these letters with more than usual care, he wrapped them up in a sheet of parchment and took them to Haarlem. The next day, upon unwrapping them he was astonished to find his monogram perfectly produced on the parchment in bistre, by the action of the sap through exudation.

It was a revelation. He cut some other letters in wood, on a large block, substituted a black liquor for the sap. He had in reality advanced to the point in printing occupied by the Chinese, but he knew it not. He submitted his discovery to his friend Gutenberg, who saw, as by inspiration, that a great discovery had been made. He examined it in every possible aspect, he borrowed it, and the next day left for Strasburg, where he shut himself up in a laboratory, and there gave himself up to study. Here he fashioned his own tools; he experimented, broke, adopted, rejected, until at last he secured an outline of an impression on parchment from movable characters, made from wood, which had a little hole through each of them through which a thread was passed which held them in place, and on the face of which there appeared in relief the letters of the alphabet.

How far this incident may be true, cannot be told, but it is at least worth relating, as it shows a connection between Coster, whom the Dutch regard as the inventor of movable types, and Gutenberg, who has the credit of the most of the world as the one to whom the honor of the invention should be given.

The account then continues: He was so distracted with his success that he could scarcely sleep the following night. In his troubled sleep he had a dream, which he himself recounted to his friends. This dream was so prophetic, and so near the truth, that no one who reads it can doubt that it was as much the reflection of a sage awake as the feverish dream of a sleeping artisan. This curious dream is found in the library of the Aulic Counciller Beck, and is as follows:

Gutenberg fell asleep in a delirium, murmuring, "I am immortal!" And then he heard two voices which spoke to him alternately. The first said: "Rejoice, thou

art immortal! Henceforth all light will expand through thee in the world! The peoples who live thousands of leagues from thee, foreigners who think not the thoughts of thy country, will read and comprehend all the thoughts, to-day mute, but which through thee, through thy work, will expand and multiply throughout the entire world! Rejoice, thou art immortal; for thou art the interpreter which awaits to assist the nations in conversing among each other! Thou art immortal, for thy discovery will give immortality to genius which would be still-born without thee, and which in its turn will immortalize the one who has made its name eternal!"

The voice then became silent, and left him in a delirium of ecstacy. Then said the other voice: "Yes, thou art immortal; but at what price? Are the thoughts of thy fellow-men always so pure and holy that they merit being transferred to the comprehension of the human race? Are there not many of these thoughts, the greater number, perhaps, which deserve more annihilation than they do to be repeated and multiplied in the world? Man is oftener perverse than wise and good; he will profane the gift which thou wilt make him; he will debase that which thou hast created for him! In a century or so, thou wilt be cursed in place of being blessed!

"Men will be born whose wit will be powerful and seductive, but whose hearts will be arrogant and corrupt; without thee they would have rested in the shadows; enclosed in a narrow circle, they would have never carried unhappiness only to their immediate surroundings and to their own lives; through thee they will disseminate madness, wretchedness, and crime through all men and all ages! See the millions of souls corrupted through the agency of a single one! See the sons perverted by books whose pages give out a moral poison! See the

daughters become immodest, unbelieving, severe to the poor through these books into which have been poured the poisons of the soul! See the mothers who weep for their sons! See the fathers who blush for their daughters!

"Is not the immortality which costs so many tears and so much anguish, too dear? Dost thou desire glory at this price? Dost thou not shudder at the responsibility which will be cast upon thy soul? Believe me it is better that thou shouldst regard thy invention as a ravishing dream, but baleful, and which would be useful and holy if man were good! But man is wicked; and to give arms to the wicked, is it not to become a participant in their crimes?"

It is related that Gutenberg then awoke, and said: "I awoke in the horror of doubt! I hesitated an instant; but I considered that the gifts of God, while they are often perilous, are never bad, and that to give another weapon to reason and to liberty was to give a field more vast to intelligence and virtue, both of which are Divine!

"I followed on in the execution of my projects." *

It may be that there was such a dream; and whether or not there was one, there is much in it to evoke thought. But we may conclude that, however foreboding were the words of the warning genius of the dream, the balance of the account of humanity has been on the side of right. So commanding have been the results for the right through the instrumentality of the press, that even thrice the amount of harm it may have done would not outweigh them. It may have here and there been the instrument of oppression, of immodest lives, of impure sentiments; in fact it has been this, but even then it can be forgiven. That Peter slept a moment in the

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* Translated from the original into French by Garand.

Garden was a grave fault, a striking act of ingratitude, but it does not obliterate the services of a life devoted to his Master; nor do the exceptional lapses of the press militate against the belief that its labors, in the great majority of cases, have been in the interests of the twin divinities, Intelligence and Virtue.

Gutenberg soon saw the tremendous value of his invention, and at once took steps to utilize it to its full extent. To secure this end, he was forced to associate himself with men who had the necessary capital, and mechanical skill. In the pursuit of this end he had several partners, among whom was Faust, goldsmith and banker at Mayence, and who has often been popularly supposed to be Faust, the magician who sold himself to the evil one for a renewal of his youth. The partnership was for the purpose of carrying on a trade in jewelry, watchmaking and the like; meanwhile Gutenberg continued his labors in secret in perfecting his invention, while openly, he labored at other handicrafts. He cut precious stones, and in other labors kept himself before the public, and his associates, in order to the more effectively conceal his real effort. But despite all his precautions, the fact that he did work in secret became noised abroad, and the superstitious animals by whom he was surrounded began to have, and impart, suspicions that he was a sorcerer, and engaged in unholy labors.

To avoid anything like publicity, he left the city and erected his workshops in the ruins of the monastery, known as the convent of St. Arbogaste. There, in a secluded locality, inhabited only at times by wandering tramps from the city, he carried on his labors. He reserved to himself a cell, which he had fitted with bars and locks, and in which he pursued his investigations. It was given out, and believed that he was occupied in

designing various patterns connected with the ostensible business of the firm with which he was connected; but it was there that he cut his letters, and planned the use of metal for his types, and studied out the thousand and one problems which would assuredly present themselves at the outset of his invention. He manufactured a model for a press, and gave it to a turner named Saspach to make in full size. An imaginative French writer relates that the mechanic took it in his hands, examined it on all sides with disdain, and then, with an air of raillery, said:

"Now, are you quite sure that it is a simple press that you wish me to make?"

"Yes," answered Gutenberg in a grave and exalted tone; "It is a press, in fact; but it is a press which will throw forth in ever-flowing waves the most abundant and the most marvelous liquor which has ever existed to quench the thirst of man. Through it, God will expand His Word; it will become the source of a pure truth. Like a new star, it will dissipate the shadows of ignorance, and inundate mankind with a light which they have never yet known." *

His first books are supposed to have been of a sacred character; indeed they were likely to be, as religious MSS. were the only matter within his reach. It is said that the Psalms and the Latin Bible were the first of his works. "Praise and prayer were, under the hands of this pious man, the first voices of the Press." There are no means of identifying any of his works at this period, for the reason that he did not attach his name to any of them; and, hence, it is the most attenuated of conjecture which assigns any book as the work of his press.

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* Lamartine.


The first boke of Mo... es.

And God sayde: let there be a firmament betwene the waters, and let it deuyde y^e waters a sunder. Then God made y^e firmament, and parted the waters vnder the firmament, from the waters aboue the firmament: And so it came to passe. And God called y^e firmament, Heauen. Then of the euenynge & mornynge was made the seconde daye.

And God sayde: let the waters vnder heauen gather them selues vnto one place, y^t the drye londe maye appeare. And so it came to passe. And God called y^e drye londe, Earth: and the gatheringe together of waters called he, y^e See. And God sawe y^t it was good.

And God sayde: let y^e earth bringe forth grene grasse and herbe, that beareth sede:

REDUCED FAC-SIMILE OF FIRST PAGE OF COVERDALE BIBLE, 1535.

(Size of original, 6x9½ inches.)

But now, when his grand invention was fairly launched, the real troubles of his life began. In order to continue his labors, more capital was necessary, and to obtain this he had to admit several people into an association. Then came long and tedious litigation. One of the heirs of one of his partners commenced proceedings to compel him to admit that the invention was not his own, and to prevent his having anything further to do with the business. Gutenberg underwent an examination of great length, and which placed him in a peculiar position. In order to defend his rights, he was under the necessity of explaining his secret; but this he was not prepared to do at the present stage of the invention. He was pressed by the judge with all sorts of questions. "He eluded them, preferring condemnation to the vulgarization of his art." He lost the case, and was ruined. He returned to his native town, and made another effort to carry out his plans.

At this point there occurred a bit of romance in his active life. The second time that he was expelled from his native town, he was under an engagement of marriage to a young lady named Annetta. She kept her faith, and waited during all his absence. When he returned to Mayence, he made no movement to redeem his pledge to his *fiancée*, perhaps not wishing to drag her into the poverty which was now his fate; or perhaps his sentiments had undergone a change, owing to his devotion to his new idol, the art of printing. She besought him to redeem his promise; and he finally was induced to keep his word, only by the institution of judicial proceedings. The summons secured by the young lady is yet in existence. They were married; they had some children, but none of them lived beyond childhood.

He soon after returned to Strasburg, and opened a workshop in the city. This was in 1439; but in 1446, he

was again forced to leave. Some of his workmen started the printing business after his departure, and soon acquired fame and fortune. Gutenberg returned to Mayence, took as partners two men, erected shops, and once more began the business of printing. It was then that he brought out what is substantially his first authentic work. He printed the Psalter, and the Mayence Bible; the first bearing date 1457. After these sacred books were finished, the works of Cicero were next in order.

His future seemed assured, but it was not. His partners, emulous of the glory which he was acquiring, began a series of legal prosecutions which ended in the defeat of Gutenberg. He once more became a wanderer; his children were dead, his wife attended him faithfully through all his vicissitudes, but she succumbed, and was laid by her children. Old, without food, Gutenberg was a pitiable object, without wife, home, or children; but at this critical moment he was offered a home by Adolphus, the elector of Nassau. And now, thus bereft of all that would make life desirable, he remained in such comfort as could be afforded by an abundant hospitality, carrying on his favorite pursuit until his death. By his will, he left his sister, who was in a convent, all the books which he had printed while a recluse in St. Arbogaste. He died, but his works lived after him. It was but a short time after his death that printing presses were in use in most of the capitals of Europe.

The progress of the invention of printing was as rapid as one would expect considering the character of an age in which there were so few readers; but the progress was not always attended with sunshine. Stephen Dolet, who was born at Lyons, France, in 1509, was a man of high attainments. He had while young filled responsible positions in the diplomatic service. He had

studied and acquired high honors at Toulouse; was a man who was at once poet, logician, and a cosmopolitan. He became a printer, or publisher, and took some part iu the furious discussions which then raged concerning the doctrines of Luther. He was arrested and thrown into prison. Through the intercession of Bishop John Pinus he was released, but refusing to voluntarily quit Toulouse, he was finally banished.

Returning to Lyons, he obtained, after immense effort, the privilege to print his *Commentaries on the Latin Language*, a work of great learning. An attempt was made to kill him about this time, but he succeeded in killing his assailant, and was then locked up as an assassin. He was released by Francois I., and was for a time under the patronage of the queen of Navarre. He next proceeded to print successively several very valuable works; but in 1542, the persecutions of him were recommenced. Various petty annoyances were resorted to, but these not having the effect to drive him out of the business, some vague charges of heresy were brought against him; his books were burned by order of parliament, and he was thrown into prison for fifteen months in Paris. He was finally released, and returned to Lyons, instead of quitting France as he should have done. At Lyons, he published a poem on his captivity, and a translation of the *Dialogues of Plato*. He was again thrown into prison in 1544. Suspicious of the impartiality of his judges he succeeded in making his escape from prison, and went to Piedmont. From thence he wrote to the king in verse imploring his protection, but unable to await the response by the usual routes, he determined to go, and see in person, what effect was being produced by his letter. He returned secretly to Lyons, but was recognized and arrested. He was tried before the theological faculty of Paris, where he was

condemned as a relapsed atheist for passages in his books which, for the third time, he protested vehemently that he had never written.

He was then put to the torture in order to make him reveal his accomplices; then he was burned at the stake; "his body and his books were converted into ashes, and his property was confiscated." But fanaticism did not stop the progress of the new agency of civilization; and the work went on as if Gutenberg had not died in poverty, and Dolet had not been burned at the Maubert square in Paris.

CHAPTER VII.

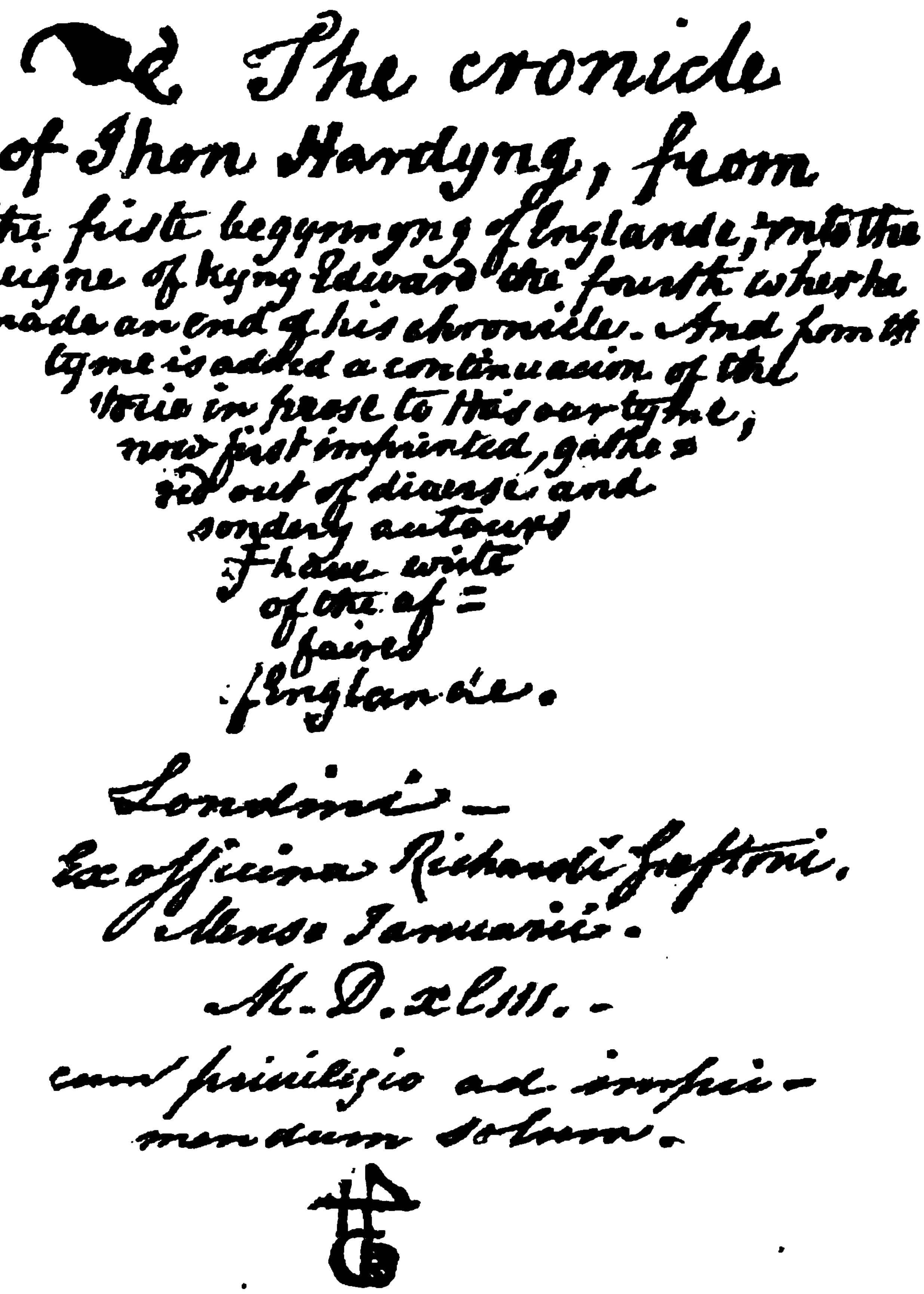
THE PROGRESS OF PRINTING.

THE new art spread rapidly over almost every portion of Europe. Men and women of the highest rank were proud to become patrons of it, and in some cases to give its practical details their personal attention. "Sovereigns themselves," says a French writer, "prided themselves for engraving and printing with their own hands the newly-found works of antiquity, as if their manual participation in the labor of the great work of genius made them a sharer of the honors of genius itself." Marie de Medicis, the wife of Henry IV., designed and printed some stamps for the royal editions. Louis XV., when a boy gave considerable attention to printing, and with his own hand performed the work on a book on European geography. "The grand printers of the centuries which followed Gutenberg were, at the same time, artists, sages, and writers. They exhumed antiquity in its entireness; and in this labor of exhumation, they took the greatest works, commented on them, explained them, and interpreted them to the new world. History was born again in the invention of printing." *

Venice did most of the printing at this period of its history. As early as 1462, before Columbus had

* Lamartine.

discovered America, all the great cities of Europe had their houses of publication. The new art had spread like a conflagration. Within the next ten years the Caxton


The cronicle of Jhon Hardyng, from the firste begynnyng of Englande, unto the reigne of kyng Edward the fourth wher he made an end of his chronicle. And from that tyme is added a continuacion of the storie in prose to this our tyme, now first imprinted, gathered out of diverse and sondry autours that have write of the affaires of Englande.

Londini.

Ex officina Richardi Graftoni.

Mense Januarii.

M.D.xliii.

Cum privilegio ad imprimendum solum.

FACSIMILE OF MS. TITLE PAGE OF "THE CRONICLE OF JHON HARDYNG, 1543."

press had been set up in Westminster, England. There are many noted names connected with this period of the history on printing, among whom was the Italian Aldus—whence the renowned "Aldine" press—the Etiennes in

France, and Caxton in England. The Etiennes were interfered with a good deal by the clerical authorities for some errors, or asserted errors in an edition of the Bible, and were driven from point to point; were imprisoned by the Calvinists in Geneva for something printed not complimentary to the Reformation; but for over one hundred and fifty years, they and their descendants were at the head of their profession. The Didot line of printers of France was also a long and a famous one. Caxton, in England, is probably the most famous of them all.

Of himself Caxton said, or rather, wrote: "I was born and lerned myn englissh in Kente in the weald where I doubte not is spoke, as brode and rude englissh as is in ony place of englond." In this "weald," a country covered with a dense forest, and whose chief industry was the raising of wild hogs, the great printer was born in 1491. He was apprenticed to a wealthy mercer, but his master died and he was sent over to the low countries, as was customary in those days in the case of young men that they might learn trade and good manners. He occupied many positions of trust, but in his old age he turned printer. He established himself at Westminster, and issued his first work *The Recuyell*, which was issued before 1447. His next was *The Game of Chess*, and the next *The Life of Jason*, all anterior to November, 1477. During the course of his career as a printer, he issued about a thousand books, in some six different kinds of type, and of which some were illustrated with wood-cuts of his own manufacture. The total product of his press is estimated at eighteen thousand pages. He died in 1491, just on the eve of a discovery that was to vitally affect the destinies of all the nations. It was written of him after his decease: "Of your charitee pray for the soul of Mayster Wyllyam

Caxton, that in hys time was a man of moche ornate and moche renomned wysdome and connyng, and decessed ful crystenly the yere of our Lord MCCCCLXXXXJ."

> "Moder of Merci shyld him fro thorrible fynd
> And bring hym to lyff eternall that neuyr hath ynd."

Caxton to-day is regarded in England, with reference to printing, what Columbus is to America. He made his own paper, cast his own type, constructed his own presses, and did his own binding. Some of his works are still in existence, of course not in circulation, but held as mementoes in various libraries, and in the antiquarian collections of private gentlemen of wealth.

Printing gave an extraordinary impetus to learning, so much so that in a century it had almost revolutionized the world's intellectual condition. But there was still new worlds for it to conquer, and to bring this about there was a necessity of an alliance between it and some other forces. At this period in the fifteenth century, the process of printing a book was a long and tedious one. The type at first in use were made to imitate the writing of the scribes of the period. It was hard to decipher, unhandsome in appearance on the printed page; but the greatest obstacle was the slowness of the press-work. There is evidence that Caxton "set up" a page in type, and then proceeded to print off that page before going on with the next one. In many cases the Chinese style was followed in which two pages were printed, and then these two folded back to back, leaving the intermediate two pages blank. The process of printing the impressions from the page of type was a slow one. Being printed, one page at a time, and with a most inferior press, it was a Herculean labor to issue a complete book. The press was a most primitive machine, in which the page of type was laid face uppermost

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on some solid support, and then the paper pressed down on it by a platform lowered by a screw passing through a support above. What was needed was something which would aid in the distribution of printed matter; make it more rapid, and less laborious. Then there was a search for an improved press. In time there was something of an improvement. The hand-press now and then added a feature of value. The toggle-joint was a vast advance in the use of the lever; but it

ANCIENT PRINTING OFFICE.

remained for the nineteenth century to make the press what it is to-day.

Various kinds of hand-presses succeeded one another, but it was not till near the close of the last century that the modern power-press was discovered, or invented. There were the Stanhope press, the Franklin of more than a century ago, the Columbian, and Washington

presses; and near the close of the last century, there was an attempt to secure a power-press by the invention and the patenting of a cylinder printing-press; but the first effort of the kind which took practical shape was the invention of a German named Koenig, and which was adopted by *The Times* of London. It was first used in November, 1814, and was the first press ever run by steam. Its best work was about eighteen hundred impressions an hour. From this time forward, the improvement in this class of machine continued, until we have to-day presses which will throw off completely printed, and folded, more thousands per hour than the hundreds of the primitive press of Koenig. In these modern machines, for newspaper work, the blank paper is taken from an endless roll through the machine, which prints it on both sides, cuts off the sheet, folds it and numbers it. There are several of these "perfecting presses," as they are called, among which the Hoe, the Bullock, the Walter, are the most noted. The Walter press is in use in the office of *The Times* of London, and is the invention of an employé, although named after the editor of the sheet. It is a very rapid machine, but insufferably noisy. Many of Hoe's presses are in use in England, although an American invention. There are many other perfecting presses, which work with prodigious rapidity, and in this respect, they are being constantly improved. From a speed of eighteen hundred an hour to that of twenty thousand, in less than seventy years, is a remarkable progress in this invention, but it becomes still more wonderful when it is considered that the greater portion of this progress has been made within the last twenty years. With the hand-press, the result of a day's hard work was low down in the thousands; now what a hand-press could do in ten hours can be done by a modern press in as many minutes.

Thus reinforced by the modern perfecting press, driven by steam, the invention of printing has reached what may seem the limit of its advance. It may be that there may be a further reduction in the time required to print a newspaper, but there cannot be much. Time is now practically annihilated. The great modern newspaper can keep its columns open for the reception of news until a given hour, and thirty minutes later can have the papers on the street, or speeding away on the early trains to all parts of the country. The man who gets an enterprising newspaper just fresh from the press can know all the events of importance which have occurred up to an hour previous to the time when he purchased it. Printing is at the foundation of these results; but it has added to itself an army of auxiliaries to attain this perfection. The lightning-press is one of the assistants, the process of stereotyping is another, and the telegraph is the third and most potent of all the forces which have allied themselves to, and enlisted under the banner of, Invention.

The first newspaper printed is said to have been the *Gazette de Venice*, in 1563; the next was the *Gazette de France*, in 1631; the London *Gazette*, in 1642; the Dublin *News-Letter*, in 1704; the Germans had their first in 1715; the first in this country in Philadelphia, in 1719; and the next in Holland, in 1732. Since the establishment of the newspaper in this country, the increase has been enormous, until the present, when we now have an aggregate represented by a very substantial fractional number of all in the world. The newspaper is not precisely a part of the history of printing; but it is a result which cannot wholly be ignored in ascertaining the credit due to the invention of this art. The daily issues of the newspapers of the world amount to millions of copies. They are read everywhere, by everybody, and

THE HOE-PERFECTING, TYPE-REVOLVING PRINTING MACHINE.

beyond all question are the most potential of all the results which have flowed from the invention of Gutenberg.

It may be of interest to state that the first press which came to this country was to Mexico, in about the year 1500. The next was at Lima, 1686, and the first in the United States, or rather in what subsequently became the United States, was at Cambridge, in 1639. In 1709, a press was put up at New London, Connecticut; at Annapolis, in 1726; at Williamsburg, Virginia, 1729; at Charleston, South Carolina, 1730; at Newport, Rhode Island, 1732; at Halifax, Nova Scotia, 1751; at Woodbridge, New Jersey, 1752; Newbern, North Carolina, 1755; Portsmouth, New Hampshire, 1756; Savannah, Georgia, 1763; Quebec, Canada, 1764. The first press west of the Alleghanies was at Cincinnati, in 1793; and the first west of the Mississippi, at St. Louis, 1808.*

* Edward H. Knight.

CHAPTER VIII.

THE MARINER'S COMPASS.

THE fifteenth century is a grand one in that it saw the renaissance of the human race, of that portion of it which has since become the abode of civilization. It gave the world artists whose works have never been excelled; it gave us printing, and it gave us the discovery of America. But before these potential events took place there was another, scarcely less potent in its influence than any of the others; and which began the labor of changing mankind from a series of warring tribes into one great family. Anciently, nations were in dread of each other, or jealous, or suspicious. If they intermingled, it was usually sword in hand and prepared for the worst. The visits were rare; each people kept jealously to itself any invention or improvement that it possessed. The nations were as would be a great area peopled by different communities, and so separated by natural obstacles that intercommunication would be a matter of the greatest difficulty. In such a case the residents of each community would very naturally rally about itself. It would gradually grow to distrust the character, the motives, of all the others. Each would see that what it knew of value in offence or defence, and which it esteemed to be especially valuable should not get to the knowledge of the others. As a consequence, advance would be hampered. On the other

hand, if there were a free interchange of views, of discoveries, there would necessarily follow improvement.

If this one should invent gunpowder, being a thing of value and utility, it would be beneficial in proportion as its uses were extended to others. A machine for reaping would be valuable in proportion to the extent to which it should be known. As with small communities, so with nations. In proportion as useful appliances became known and distributed, the average of the comfort of the human race would be increased. From this point of view great inventions are valuable in proportion to the number of people whom they reach.

As if expressly designed to meet this requirement, the invention of printing was preceded by another without which the inestimable value of printing would have been small compared to what it has become, thanks to the invention which preceded, and which brought the remotest parts of the world into contact. Without the mariner's compass, inventions would have centered about a small spot, and would have conferred their benefits on the few. Indeed, the limit of invention itself would be very materially circumscribed had not the needle been ready to assist in distributing its work; for, without the increase of area which the compass brought to the knowledge, one-half, or more, of the necessities which have stimulated invention would have been unknown.

As to the inventor of the instrument known as the mariner's compass, there is nothing certainly known. It is true that a certain number of authorities unite in a conclusion to the effect that it's first use in Europe is due to Flavio Gioja in the early part of the thirteenth century. Others again are of the opinion that it was brought to Italy from China, in 1295. There are still others who are of the belief that it was used in France

in about the middle of the twelfth century, in Syria at about the same time, and in Norway previous to 1266.* But there is no satisfactory proof of the truth of any of these theories. There is very excellent authority for the conclusion that the virtues of the magnetized needle was known to the Chinese 2364 B. C. A Chinese dictionary published 121 A. D., speaks of a loadstone, as a "stone by which attraction is given to a needle." The Chinese have long used a needle for navigation, exactly like ours in fact, but unlike us they give their attention to the south end of the needle instead of the north. It is quite a possible thing that the needle was brought by the Arabs to Europe, and then was introduced to the other peoples along the north coast of the Meditterranean.

Of the claim of Flavio Gioja, Barlow says: "The lame tale of one Flavio Gioja of Amalfi, in the kingdom of Naples, to have devised it, is of very slender probabilities." Col. Yule, *Book of the Mariner's Compass*, says: "Respecting the mariner's compass, and gunpowder, I shall say nothing, as no one now believes or imagines Marco Polo to have aught to do with their introduction." Another writer believes it to be a thousand years older than Christianity." †

There are some who are of the opinion that the compass was brought home by the Crusaders; and there are others who have still a different conclusion. From this array of opinions, it is easily seen that there is nothing known in reality; and that of the various opinions most likely to be true, is the one which ascribes its origin to the Chinese; and to whom we are indebted for so many other inventions, and discoveries which are popularly supposed to be of modern origin. Up to the period

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* *Am. Cyclopædia.*

† "L' usage de la boussole etait connu en Chine plus de mille ans avant l' ére Chretienne." Despres.

when the mariner's compass came into use in Europe, such navigation as there was, was done within sight of the land. Certain headlands along the Mediterranean became landmarks, and the navigators, by keeping in sight of them, were always able to reach their destination. Sometimes, in case they were blown out of sight of land, they were in the habit of freeing birds, and then judging of the direction of the land by that of their flight. The biblical student will remember an incident of this kind which is related in connection with Noah's voyage in the ark, with the difference that the dove returned at first because it had found no land on which to rest the sole of its foot; and that when it came back after having been released the second time, it bore in its beak a green leaf, thus showing that the waters had uncovered the land. In other instances, when the sky would permit, the seaman held his course by the light of the polar star.

It is perhaps worthy of mention that the loadstone, or magnet, is known as "handhakogohah" or "the stone which loves," among the East Indians; and among the French it is termed "aimant," meaning "lover;" in both cases being evidently thus named on account of its qualities of attracting to it and holding, as it were, in a loving embrace the object to which it clings.

"The compass," says Racine, "makes us all citizens of the world." This is the fact. Without the compass there could have been no discovery of America from Europe; and, in every probability, without it, this country would have been in about the same condition to-day that it was anterior to the year 1492. The copper-colored aborigines would have been hunting the buffalo over all the country west of the Alleghanies; and where the great city of New York now stands, there would

have been a few tepees; and some tawny fishermen would have been dropping their bone hooks into the waters of a harbor that now floats annually a tonnage equal to that of the entire world. The fifty millions of people who are now here would neither have found birth or existence in the crowded areas of the old world; and it is doubtful if, in progress, the human race would have been far in advance of its resting-place in the fifteenth or sixteenth century. It was essential to the outcome which destiny was working out for mankind that there should be room made for the millions who were each decade or so being added to the population of Europe; and this room was to be found in a new world, without traditions, without any divinely-commissioned autocrat to sway the destinies of a nation; and where there could be, without interruption, the travail of humanity—the birth and growth of a new civilization.

As it was not so very long after the mariner's compasss had come in use that Columbus made the voyage in which the American continent was discovered, and as the two are so intimately associated in the enormous continent which was soon to be added to the known areas of the earth, it may be of interest to reproduce the interview which was held between Columbus and the council of examination at Salamanca, presided over by the prior of Prado. Peliminary to this there is a picture of Columbus, as weary, foot-sore, almost discouraged with the rebuffs which he had everywhere met in his efforts to secure sufficient patronage to enable him to test his conviction that there was to the westward a new world. In this description he, accompanied by his son, a youth of sixteen, is at the monastery of Rabida, and it is the superior who learned to respect and love him. "That which he loved," says the writer, "was not only his grand design, but his courage, his modesty, his

gravity, his eloquence, piety, gentleness, virtue, grace, patience, his noble bearing under the weight of misfortune, all of which revealed in this wandering stranger one of those natures characterized by a thousand perfections, and so stamped by the divine seal that he could not be forgotten, and which forced him to be regarded as a man without an equal." And then comes the examination before the board.

Ferdinand, king of Spain, after having heard Columbus, named a council, composed of men versed in the divine and human sciences of Spain and Portugal. They assembled at Salamanca, the literary capital of Spain, in a convent of the Dominicans. The priests and the religeux then decided everything for all Spain. Civilization was then in the sanctuary. Kings only reigned on their merits, or acts, and everything in the nature of ideas emanated from the pontiffs. The inquisition, the sacerdotal police watched, arrested, struck, close up to the very throne, all that which had about it the smallest taint of heresy. The king had added to this council some professors of geography, astronomy, and mathematics, and of all the professed sciences at Salamanca. This gathering did not intimidate Columbus; he flattered himself that he was to be judged by his peers, and not by those who contemned him.

When he appeared in the grand hall of the monastery, the monks and the pretended savants, convinced in advance that every theory which was outside of their ignorance, or their routine knowledge, could only be the dream of a diseased spirit or an enthusiast, saw in this obscure stranger one seeking a fortune by the aid of his chimeras. Nobody deigned to listen to him with the exception of two or three members of the convent of St. Stephen of Salamanca; people who were obscure and without authority, and who had access in their cloister

to studies despised by the superior clergy. The other examiners of Columbus confounded him with citations from the prophets, the gospels, and the fathers of the church; and which, in advance, annihilate, by indisputable texts, the theory of a globular form of the earth, and more especially that of the existence of the antipodes. Among others, Lactance said:

"Can anything be more absurd than to suppose there are people opposite us who have their feet opposed to ours, or men who travel with their heels up and their heads down, or a world in which the trees grow with their roots above, and their branches in the earth?"

Augustin, afterwards canonized, went even still further than the other, for he characterized as a sin any belief in the antipodes; "for," said he, "it would be to suppose the existence of some nation which has not descended from Adam; and the Bible has declared that all the nations of the earth have descended from one father."

Some of the other doctors, mistaking a poetic metaphor for genuine cosmogony, cited the words of the Psalmist in which he says the Lord extended the heavens above the earth as a tent, from which it must result, according to them, that the earth must be flat.

Columbus responded in vain to his examiners; he proved himself to be more religious, and more orthodox than they, because he was more intelligent and more enthusiastic in what he believed to be his divine mission. All the thunders and the lightnings of his eloquence were lost in the voluntary darkness of his listeners. One or two made some effort to defend him, but the burden was too great; but even reinforced by this assistance, he accomplished nothing. Meetings of the conference continued to be held, but nothing could overcome the obstinate indifference of his examiners.

The conference languished, and wore out the truth by delays, which are the last refuge of error.*

It was against such a spirit that advance had to move at this age of the world; and it is rather mortifying to reflect that a nation which treated Columbus with such indignity, and in a spirit at once malignant, brutal, and ignorant, should be the one to whom should finally accrue the credit of a discovery of a new world. It may be, however, that this contumely afterwards met its reward. The wealth which fell into the hands of Spain may have been one of the potent causes which, in time, hurled her from her lofty position to the one which she now occupies. The atrocities which the Spaniards inflicted on the gentle and trusting Americans for the sole purpose of wringing from them their gold, are the most shameful of all the horrors narrated in history.

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* *Œuvres de* Lamartine.

CHAPTER IX.

THE PERIOD OF THE NEW BIRTH.

THE word Renaisssance is usually applied to the revival, or rather the rise of art which followed the dark ages. There is no good reason why this word should be restricted to painting and architecture. It was a period when everything experienced a new birth. The art of printing was as much re-born as any department of painting and sculpture; and as its influence was much more potent than that of any other agency which made its appearance at this time, it has the right to be termed a portion of the Renaissance. In fact, the art of printing extended at once from Germany into Italy after its invention, and there immediately established a foothold that it long retained. It was at this time that the Renaissance in Italy received a stimulus that speedily placed it at the head of every centre of improvement in Europe. It did a majority of all the printing for all Western Europe, for the reason that it possessed greater taste, and better facilities for the transacting of the work demanded. One reason why printing so flourished in Italy is to be found in the fact that the soil had been prepared for it, and when once transplanted thither, it took immediate root, grew and flourished beyond parallel.

Dante had lived and written in the thirteenth and fourteenth centuries, and preceding him had been a host

of poets and writers, all of whom had been preparing the ground for what was to follow. At the beginning of the fourteenth century Dante had written his *Divina Commedia*, a work which is as fresh to-day as when, nearly six hundred years ago, it was given birth. It is a production whose influence on taste has never been excelled by that of any other work. Soon after Dante had made his appearance on the literary stage, he was reinforced by Petrarch and Boccaccio, and who formed with him what has justly been termed "that great triumvirate which gave to the fourteenth century its glory in Italian history." Of the innumerable writers of that period, these three have survived; and to-day are as bright stars in the literary firmament as any of which the world has ever known. In the fifteenth century, printing made its appearance, and thereupon Italian literature advanced steadily until the sixteenth century, which is considered the Golden Age of the Italian nation. It was this century which produced Ariosto, Tasso, and others whom the world delights to honor by remembering, by its unalloyed admiration. In the fifteenth century the renowed Macchiavelli made his appearance, and gave utterance to political thoughts which have not yet been forgotten, and which still are of valne to the politicians of the present time.

All this revival, or rather birth and spread of literature, is owing mainly to the invention of printing. It gave the world at that remote epoch a literary splendor which has rarely if ever since been excelled. Poetry, history, comedy, opera, all had their origin in this wonderful era; and what was then written, painted, and sung has influenced human progress from that moment to this, without intermission, or abatement of strength. But it is not alone in literature that there was such progress made. More than even in this direction did art

exert itself; and glorious as is what was accomplished by the former, the latter even excelled it. At about the time when printing obtained possession of Western and Southern Europe, Dürer, Michael Angelo, Raphael, Da Vinci, Guido Reni, Il Tintorretto (Giacomo Roberti), Paolo Cagliari (Paul Veronese), became prominent as painters, and in the cases of some of them, as mathematicians, and scientific experts; and the success which they attained has been marvelous beyond estimate. In the new order of things Italy took the lead. It was Italy that furnished the cradle in which was rocked the new-born of civilization. In addition to the long list of authors, artists, mathematicians, it gave the world other names which are immortal. It was in the fifteenth century that Columbus was born, that Amerigo Vespucci, who gave his name to this great hemisphere, first saw the light. It was Italy that gave birth to Galileo. Surely the world is under irredeemable obligations to the peninsula in which the ancient civilization was buried, and the modern one was born.

Copernicus, who first strongly enunciated the idea that the earth and other planets move about the sun, was the product of this marvelous fifteenth century. Amerigo Vespucci was born in 1415; Bacon came in the middle of the next century; Galileo was his cotemporary; the way was being prepared for Newton and his immortal discoveries. What fame these men attained; to what extent they have become immortal; the vast benefits which they conferred on mankind; all are largely due to the invention of the art of printing. Luther was close at hand to give his aid to the great labor which was being performed by the world at this most important era.

"Three sons of serfs, heroic workmen, shaped the three stones on which the new church was founded; Columbus, Copernicus, and Luther. The Italian found

the world; the Pole found its movement, and the harmony, and the infiniteness of the heavens. The German reconstructed the family, and reared within it a sacred altar. He sought to found the world upon man. Effort enormous, unique! Never before were such obstacles to be encountered." *

The progress of the Renaissance in England was much slower than in Italy. Perhaps the stolidity of the Saxon constitution was less easily affected than the more vivacious and volatile Italians. The first results of the invention of printing was to bring into England translations of the classics, and it became the fashion to study them. Many of the historical women of the age were able to read the prominent Greek and Roman authors in the original. Warton says that before 1600, all the great poets were translated into English, and between 1550 and 1616, all the great historians of Greece and Rome. "After the terrible night of the middle age," says Taine, in referring to this period in English literature, "and the dolorous legends of spirits, and the damned, it was delightful to see again Olympus shining upon us from Greece; its heroic and beautiful deities once more ravishing the hearts of men. They raised and instructed the young world by speaking to it the language of passion and genius; and the age of strong deeds, free sensuality, bold invention had only to follow its own bent, in order to discover in them the eternal promoters of liberty and beauty." While England took readily to the paganism of the Greeks and the Romans, in the literature with which the printing-press was flooding it, it did not look so favorably upon what began to flow from Italy at the same time. The productions of the Italian authors, to whom allusion has been made in this

* *Histoire de France.* Michelet.

chapter, did not suit the sternness of the Saxon character. It was too warm, too imaginative, too voluptuous. In 1507 it was written:

"These bee the inchantmentes of Circes, brought out of Italie to marre mens maners in England; much by example of ill-life, but more by preceptes of fonde bookes of late translated out of Italian into English, sold in every shop in London. There be moe of these ungratious bookes set out in printe wythin these few monethes than have been seene in England many score yeares before. Than they have in more reverence the triumphes of Petrarche, than the Genesis of Moses; they make more account of Tullies offices than S. Paules epistles; of a tale in Bocace than a story of the Bible." *

Nevertheless, the literature of Italy made its way and held possession of the Anglo-Saxons. Many of the leading writers of the early period following the invention of printing, borrowed their style, their tone of thought, their dramatic incident free from the literature of the Italians. Readers of Shakespeare will recall how many of his characters are Italian, and how many of his plays are located in Italy. Without Italy, the world would never have had Shakespeare, at least at the period when he appeared. There might have come at some other age a something in the nature of a Shakespeare to compile, originate, invent the marvellous aggregate attributed to the Bard of Avon; for the Shakespeares, like the Napoleons, are not men, but expressions of the age in which they live. They are the escape-valve of the sentiments, the yearnings, the ambitions, the determinations of the communities in which they reside.

So far as the paganism of the new civilization of the Italians is concerned, it was soon encountered by the

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* *The Scholemaster.* Ascham. 1570.

Reformation inaugurated by Luther; and, hence, if it be charged that the heathenish Renaissance which first made its appearance in Italy owes much of its advance to the art of printing, it is equally true that printing furnished the antidote which was furnished by the German monk, Luther. Without the aid of the press he could not have made his voice heard outside of the town in which he lived. Not one-third, not one-twentieth of the people whom he must reach to make his reformatory labor of any value, would not have been reached had not the printing-press supplied him with an agency for the distribution of his experiences, his opinions, his exposures, his demands for a radical reform of the religious system with which he bad been so long connected. Without the press, Luther would be simply a monk who was dissatisfied with indulgences, who rebelled from his mother-church, but who did not inaugurate a movement which has become mightier in its volume and impetus each year of its existence, and which has eventuated in a power than which there is none more far-reaching or influential. The press was his herald. It bore his protests to every valley, every mountain top. It made itself heard throughout the length and breadth of Europe, it crossed to England and awoke with its blast the attention and the consciences of the Anglo-Saxon; it crossed the stormy Atlantic to the new world, and made itself felt among the sparse settlers with the result that the colonists laid the foundations of a structure which will last as long as man.

There is a vast deal in the Renaissance of the fifteenth and sixteenth centuries to admire, and much to deplore. It was an era in which men were at once good, bad, brilliant, learned and superstitious; a time of great advance in learning, and yet one in which the grossest ignorance of life social problems, fraternity, human,

rights prevailed. The inquisition flourished; thousands of Jews were expelled from Spain; heresy was pursued and punished as relentlessly as society now pursues and punishes murder. Everywhere there were flagrant contrasts. It was an age in which society was governed by religion, and which was yet pagan. The period was one of atheism, sometimes avowed, as often concealed under the guise of religion. There were thinkers who frittered away their time with the examination of problems of no possible value; sorcery and witches were of the commonest occurrence so far as the popular belief affected their existence. Hundreds of witches were sent to the stake in the full belief that they were leagued with the devil, and that they exerted a malign influence over the lives of others. It was an age in which genuine piety was scarcely known save in name. The priesthood was licentious and intolerant, not so much of acts as of opinion. Men who lived debauched lives encountered no obstacles, but men who ventured on conclusions outside certain limits, were suspected, and liable to be executed. The inquisition was brought from Spain to Germany, the very source of the religious reformation. Men and women were sensual; they labored more to secure enjoyment in this world than security for the next. There were no depths into which men did not descend, no heights which they did not climb.

It was a period of violent contrasts; it was a time swept by whirlwinds, and warmed by genial sunshine; there were intellectual torrents and floods which carried everything before them, and there were placid waters in restful valleys, where the air was always warm and sensuous, and where the votaries of fancy and imagination could dream their lives away without disturbance.

But all these were the legitimate results of the new birth. In the wonderful transitions which men and

women were undergoing, there could be no such thing as universal ease, harmony, and smoothness. For centuries the races of Europe had been congealed, and now the ice was breaking up. There were floods; there was the roar of the grinding, crashing ice; there were gorges, high-piled, which interrupted movement; and there was the giving way of these accumulations which bore down everything before them, which inundated the adjacent region, effacing, destroying all which barred the onward rush. There is travail in all birth. Even the mountain which brought forth a mouse, groaned, and shook in its labor.

The Renaissance was the parturition of a world. Its throes were mighty. As the mother solaces herself, in her poignant suffering in reflecting that she is, in a sense, a creator, and that she is about to give a life to the world—a new life whose caresses will reward her for her pain—so may we look on the travail which the world then endured, and feel that the new-born was destined to become a new creature, one that would gratify the maternal heart, and in this way more than repay her for all that she had endured at the supreme moment.

Out of all this evil, there was destined to come good. It was the clamor of the working-men engaged in re-erecting the structures which had been built by superstition, ignorance, and usurpation. The agencies which had forced this reconstruction of the old, the unsafe, the inharmonious; which were tearing down the uncouth and undesirable, were the inventions that preceded the work. They were the compass, gunpowder, and printing; they had shaken the world to its foundation, and they were now engaged in restoring in a new and more permanent form, and from the better portion of the old materials, that which had been thrown down.

The inventions thus far referred to, since the

awakening from the sleep of the dark ages, are not all that first came into existence during this period. Others there were which, as auxiliaries of printing and gunpowder, have been of almost supreme importance. Among these were spectacles, various improvements in fire-arms, watches, engraving on steel, the air-pump, submarine vessels, the spinning-wheel, the pendulum, the microscope, and the telescope. A brief allusion to some of these, the less important of them, will be of interest. According to the generally-received opinion, spectacles are the invention of Alexander Spina, of Pisa, some time between 1280 and 1311. Egger says that the rules for making spectacles were given in Euclid; but, despite all this, the most intelligent account of them refers them to the latter portion of the thirteenth and the first part of the fourteenth century. The principal use of spectacles is for reading; and it was not a very long time after their invention, and just about the time when they would be somewhat relieved of the crudities attending their origin, that printed books came into existence.

It was during the middle of the fourteenth century that invention gave to the world that very valuable article of industry known as wire. Anterior to its discovery, such wire as there was, was made by hammering iron or copper into very thin plates, and then cutting the plate into narrow strips. "And they did beat the gold into thin plates, and cut it into wires, to work it in the blue, and in the purple, and in the scarlet, and in the fine linen, with cunning work." * Thus of the ephod of the Jewish high priest. The process of the fourteenth century was at first confined to doing the work with a hammer, and mainly to the precious metals. Soon after, Ludolph, of Nuremberg, invented a process

* Exodus xxxix., 3.

by which the work was performed by a machine, and without the use of the hand. It was not till the sixteenth century that the English succeeded in making wire by machinery, and then it was so poorly done as to be in every respect inferior to that manufactured in the German shops. It was not till the seventeenth century that England succeeded in establishing a paying competition with foreign manufacturers, and then the business grew to great dimensions. At the present time, the drawing of wire is an immense improvement over the methods of the early days of its invention. In some instances, the hardest of precious stones are used for the plate through which the metal is drawn. So delicate are some of the machines for the drawing of wire that platinum, according to Dr. Wollaston, has been drawn to the one-thirty-thousandth of an inch, and of which a mile's length would weigh less than a single grain. By covering platinum or silver rods with gold leaf, the metal may be reduced to an incredible fineness, and yet retain the coating of gold. Brass wire is drawn to such a fineness, by even the ordinary processes, that gauze may be woven from it which shall have sixty-seven thousand meshes to the square inch.* The utility of wire is very great. It enters into the manufacture of gauze, and is woven in a loom like ordinary thread. One meets wire everywhere, from the sieve to the fence on the prairie; in strings of pianos; in fillagree work; in pins, needles; in the ornamentation of dress; in cables for the suspension of bridges; and in the innumerable uses connected with telegraphic and telephonic systems. In fine, it is an adjunct of civilization with which it would be very difficult to dispense.

The most ancient method of marking the passage of

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* *Am. Cyclopædia.*

time is that of some instrument which indicates the movement of the shadow of the sun. The sun dial is mentioned in the Bible, although it is generally credited with having first been known during the age of Anaximander, the Grecian philosopher, who was born some 600 B. C. The next agent for marking the passage of time, was the clepsydra, a water-clock, which measured time by the amount of water which escaped from it. It was simply a vase with an opening through which the water slowly passed, and the hour was designated by the height of the water in the receptacle. It has before been alluded to as the invention of Ctesibius, or rather that he made a valuable improvement in the original form of construction. He had the water drop on, and turn a small wheel which was connected with a small statue which gradually rose, and with a wand pointed to the hours arranged on a diagram. They were in very extensive use among the ancients, and later, and were only abandoned upon the introduction of the pendulum-clock. The sand-glass succeeded the clepsydra, and this, in time was displaced by clocks, although it is yet in use, not to mark the passage of the hours, but some designated comparatively short space of time. Just when clocks with wheels and weights came into use is not certainly known. From Archimedes down to the fourteenth century there have been many men credited with their invention. One was made in Magdeburg as early as 996; and there are authorities who agree that one was made by Boethius as far back as the year 510 A. D. Clocks were in use in the monasteries as early as the tenth century. In any case, clocks impelled by weights are known to have been in use in England during the thirteenth and fourteenth centuries. At the present time, we have clocks of the most ingenious construction, and whose uses are far in advance of those of the clocks of even

one or two centuries ago. A very common modern clock is one which is placed within an electrical circuit, and which was the invention of Prof. Wheatstone, an English electrician of great renown. By this, all the clocks within the circuit move their hands at the same instant, and hence all record the time, which is given out by some clock at some central point, and which has the means of recording reliable time. In many places, the central clock is located at an observatory, and from this the movement is taken by a greater or less number of clocks which may be within the circuit. There are also clocks in which the motor, in place of being a weight or a coiled spring, is electricity; in this case, the pendulum has its bob of wire, and passes back and forward between two magnets, and thus gives motion to the machinery of the clock, and at the same time acts as its regulator. Now we have clocks in which the hours, the day of the week and month are recorded, and with which many very curious attachments are in use. Watches seem to have been known in the sixteenth century, but they must have been very far from being the time-keepers that are in use at the present day. They had nothing in the shape of a balance-wheel and balance-spring; but what they lacked in value as to keeping an accurate record of the flight of time, they made up in other qualities. One writer mentioned one that was no larger than an almond. In his *Memoires*, Abbe Arnauld says that his mother saw, 1589, on the finger of Princess Anne of Denmark, who married James I., a large crystal of average size, in which there was set a watch, with all its wheels, which struck the hours, not on a metal surface, but in a manner whereby the hammer struck softly on the finger with light blows.* Watches in rings were

* *Vieux-Neuf.* Fournier.

a common article in the fifteenth century; they were also made in the form of a cross, and in various other fantastic shapes. The watches of the present day have reached a very high state approximating to perfection, among which the chronometer takes front rank, being used in cases where the greatest exactness is demanded. It is so named from the character of its escapement; and is carried so as to avoid anything like irregularity in position. Its use is mainly for sea voyages and for astronomical observations. The value of this kind of a time-keeper may be estimated when it is known that a watchmaker of England, named Harrison, received from the English government over one hundred thousand dollars for a chronometer, which made an error of less than two minutes in a voyage to Jamaica and back.

In this country, nearly every part of a watch is made by machinery, so that any piece in any one watch will exactly fill the place of a similar piece in any other watch of the same class. The manufacture of American watches has assumed prodigious dimensions in the United States, so great indeed that the American watch now enters the markets of the world and competes successfully with the long-established manufactories of the old world, both as to quality and cheapness, as well as beauty of form, and artistic finish. The principal points at which watches are manufactured in Europe are in many towns in Switzerland, and at Liverpool and other parts of England. There are also some places in France and Germany where watches are made for exportation; but the main points are those enumerated.

There were various other inventions of this, the fifteenth century, among which may be mentioned bronze cannon; an improvement in painting in oil introduced by Van Eyck, a Hollander; engraving on steel, the air-pump, the letter-post in France, and the carbine.

The sixteenth century also witnessed some very important advances in science and in the arts. The sword was changed into a bayonet and placed on the end of a musket, and the whole thus became a lance. The Copernican system, as elsewhere referred to, was introduced, and for the first time in the history of modern times, the human race began to be taught that the earth, instead of being the centre around which the sun, moon, and stars revolved, is itself but a humble satellite of which the sun is the centre. It was the sixteenth which first gave the spinning-wheel practical shape; in which a submarine vessel was launched—although submarine navigation is claimed, like so many other things, by the ancients; the microscope by Jansen, the projection of maps by Mercator, and the pendulum and improved telescope by Galileo.

CHAPTER X.

GALILEO.

PERHAPS the grandest event of the sixteenth century was the birth of Galileo Galilei, usually known simply as Galileo. He was born in Florence, Italy, in February, 1564, on the same day that a man almost equally renowned, Michael Angelo Buonarotti died in Rome.

It might almost seem as if the great soul which had disappeared at Rome had entered and vivified a human body in a new form. Both these men are so great, each in his way, that it would seem to be impossible to supply the place of the one save by the substitution of the other. The one was to mechanics what the other was to painting; each at the head of his chosen specialties, and both destined to immortality.

The contributions of Galileo to the arts and sciences are great, and deserve more than mere mention. His life is one of the most extraordinary character, attended with episodes which convulsed the world, and which are yet the subject of a hot contention as to the truth or falsity of charges made against the church which then substantially dominated the world. Some of the salient incidents of his life, and the main assertions of the two great parties who have so long fought over the treatment which he was accorded by the clerical and secular authorities, will also receive mention before dismissing

GALILEO.

(*From a painting by Ramsay, in Trinity College, Cambridge.*) (127)

the progress made by the sixteenth century. His first discovery was of the isochronism of the pendulum; that is, that it moves through differing arcs in the same time. This was followed by the invention of the hydrostatic scales, the thermoscope, the giving of a practical turn to the telescope which, according to very excellent authority, was not his invention; the pendulum-clock, and a vast number of discoveries in sciences of the most valuable character.

Galileo was of a noble family, legitimately born despite the fact that a report as to his illegitimacy was circulated soon after his death, and received by his enemies as truth for more than a century. The publication of the certificate of the marriage of his parents has been produced, and through it the malicious tongues of slander have been silenced. The fact, however, that he was illegitimate would have no effect on his works, their influence, or the loftiness of the place which he occupies in the estimate of posterity. He received a liberal education considering the poverty of his parents, who were poor although noble, and developed a very versatile talent, but was especially ingenious in mechanics. He was destined by his father to be a doctor, but fate had a more important career in store for him than the cure of bodily ailments. It was while in school at Pisa that there occurred an incident which is often related of him, and which, according to Nelli, is true. He was lying on his back in the cathedral dreamily watching the great lamp which was suspended from an arch, and which, having been drawn to one side to permit its being lighted, was swinging slowly from side to side. Galileo discovered by feeling of his pulse that the oscillations, although shortening gradually, were all made in the same time; that it required no more time for the lamp to swing from one end to the other of the longer arcs

than it did to swing between the extremes of the shorter ones; and in this way, the world became possessed of the very important fact that the vibrations of the pendulum are isochronous. His discoveries attracted much attention, and he was soon promoted to the professorship of mathematics at Pisa, for which he received the somewhat extraordinary remuneration of sixty-five dollars per annum; a salary which, as stated by Gebler, proves the estimate in which mathematics was held, and the more so when it is added that the professor of medicine in the same institution was in receipt of nearly two thousand dollars per annum. It was while he was at this university that he made his investigations into gravitation. The ancient theory of gravitation had been to the effect that the rapidity of the fall of a body depends wholly on its weight; this had been disputed by some thinkers, who asserted, *a priori*, that the fall of a body depends on its density, and not on its weight, but there had been no experimental effort. Galileo adopted this theory, and demonstrated it by climbing to the top of the celebrated leaning tower of Pisa, and dropping certain objects of different weights and densities, and at once demonstrated beyond any appeal that the fall of bodies is controlled by density in place of weight. The effect of these discoveries was to make him enemies, and, then, to escape their machinations he left Pisa, and soon after was made professor of mathematics at Padua. While here, he constructed various machines for the use of the republic, and wrote several treatises, the larger of which were "on the laws of motion, on fortifications, on gnomonic (the making of sun-dials) mechanics, the celestial globe, and on fortifications."* It was while here he invented the thermoscope, or a heat-indicator,

* Viviana.

which has led many to credit him with the invention of the thermometer; but this is not the fact according to cotemporary writers. The thermometer came later, the idea being probably taken from Galileo's instrument.

In 1597 he wrote a letter in which he stated that he was a believer in the Copernican theory as to the motion of the world, which doctrine at that time was held in abhorrence by the church element, or an influential portion of it, on the ground that it was in opposition to the teachings of the Scriptures, and the beliefs of the fathers. Galileo accepted the teachings of Copernicus, but did not deem it prudent to give publicity to the conviction till he had received some confirmation of the new astronomical theory from his own observations. A letter written in 1610, while at Padua, to Belisario Vinta, secretary of the Grand Duke, will afford a capital idea of the floods of scientific ideas which were pouring through his mind. He writes:

"Of curious and useful things I possess so many that their very abundance does me harm; for if I had but one, I should have esteemed it greatly, and perhaps, through it, I might have found that fortune which as yet I have not met with, nor have I sought it: *Magna longeque admirabilia apud me habeo* (freely rendered: I am surrounded with great projects); but they are no good to me, or rather, they can be no good except to princes; for they alone make war, erect fortresses, and for their royal pleasure spend such sums of money as private gentlemen cannot, any more than I can. The works which I principally wish to finish are these: Two books on the system of the universe; an immense work (idea, *concetto*), full of philosophy, astronomy, and geometry; three books on local motion, a science entirely new—no one, either ancient or modern, having discovered any of the marvelous accidents which I demonstrate in natural and violent

motions—so that I may with very great reason call it a new science, discovered by me from its very first principles; three books on mechanics, two on the demonstration of its first principles, and one on the problems—and though this is a subject which has already been treated by various writers, yet all of which has been written hitherto, neither in quantity nor otherwise, is a quarter of what I am writing on it. I have also various treatises on natural subjects, on sound and speech, on sight and colors, on the tide, on the composition of continuous quantity, on the motion of animals, and others; besides, I have also the idea of writing some books on the military art, giving not only a model of a soldier, but teaching with very exact rules, all which it is his duty to know, which depends on mathematics; as, for instance, the knowledge of encampment, drawing up battalions, fortifications, assaults, planning, surveying, the knowledge of artillery, the use of various instruments, etc. Besides this, I wish to reprint the *Use* of my geometrical compass, which is entirely out of print. In fact, this instrument has met with such favor from the public, that no others of the kind are ever made; and I know that up to this period some thousands of mine have been made. I will not say what amount of labor will be required to fix the period of the four new planets; a task the more laborious, the more one thinks of it, as they are separated from one another only by very brief intervals, and are very similar to one another in size and color." * The object of this letter was that he might secure some position under the ducal government which would afford him the leisure to carry out all these projected works. Fancy the intellectual activity of a man who devises all these works for his own labor!

* *Private Life of Galileo.*

They constitute enough to fill a library, and to keep employed a half dozen men during their life-time.

The next step in the career of this wonderful genius was to bring the telescope to bear on the great question which, at that time, was seriously agitating the learned world. The theories of Copernicus were broached, and secured some believers; but many were shy, on account of the hostility of the theological element, in giving utterance to their belief that the Aristotelian doctrines were no longer tenable. Such had been the position of Galileo; he had favored the teachings of Copernicus that the world was merely a very small item in the grand whole of the universe, instead of being, as was generally believed, the great centre around which the sun, stars, and planets all revolved. In a work called the *Siderius Nuncius*, by Galileo, and published in Venice in 1610, he says that he heard some ten months before "that an instrument had been made by a Dutchman, by means of which distant objects were brought nearer and could be seen plainly." This report was confirmed by one of his pupils, and this set him to thinking how the end could be attained. He finally placed a plano-convex glass at one end of a leaden tube, and a plano-concave glass at the other, by which "objects were made to appear three times larger and nine times nearer." He improved on this primitive instrument till he secured one which "magnified one thousand times, and brought objects thirty times nearer." * It is thus seen that although he did not discover the telescope, as is popularly taught; and did not have the idea presented to him by looking through a couple of glasses at a vane which seemed nearer and turned upside down; although all these popular tales have no foundation in fact—not even the one which states

* *Astronomicus Nuncius.* Galileo.

that his father was a spectacle maker—it is still true that he was the first to push the theory to a practical use, and may therefore be entitled to the credit of having made a vital improvement. In a letter published from the private correspondence of himself and his daughter, a nun, he says: "I write now because I have a piece of news for you, though whether you will be glad or sorry to hear it, I cannot say, for I have now no hope of returning to my own country, though the occurrence which destroyed that hope has results both useful and honorable. You must know then that about two months ago, there was a report spread here that in Flanders some one had presented to Count Maurice (of Nassau) a glass manufactured in such a way as to make distant objects to appear very near, so that a man at the distance of two miles could be clearly seen. This appeared to me so marvelous that I began to think about it; as it appeared to me to have a foundation in the science of perspective, I set about thinking how to make it, and at length I have found out, and have succeeded so well that the one I have made is far superior to the Dutch telescope. . . . Many gentlemen and senators, even the oldest, have ascended at various times the highest bell-towers in Venice, to spy out ships at sea making sail for the mouth of the harbor, and have seen them clearly, though without my telescope they would have been invisible for more than two hours. The effect of this instrument is to show an object at a distance of, say fifty miles, as if it were five miles off."

With his telescope he created a tremendous furore. It was a cardinal doctrine of the day that the heavens were unchangeable; this fell before his observation. He soon discovered four satellites, the solar spots, and various other phenomena of the planetary and sidereal systems, with the result that he soon began to make

endless enemies—some of whom were envious of the fame which he was acquiring, and the honors being heaped upon him—while another element found that their theological teachings were being mined at the foundations. About this time he received a most liberal offer to attach himself to the ducal court of Tuscany, a change which his biographers assert to be at the foundation of all his subsequent misfortunes. Florence, which he was about to leave, was tolerant in religious matters, had even gone to the extremity of defying a bull of excommunication issued against some of their officials, and was the place in which the expanding genius of the great discoverer would have found no obstacle. At the first, however, he had no difficulty. He was invited to visit Rome, and did so, being received with honor, and treated with the greatest consideration. But there were envious men who began to plot against him, and who finally asserted that his teachings were contrary to the Holy Scriptures. It would have been well had he paid no attention to this assertion; but he proceeded to answer it in a long letter to Benedetto Castelli in which he undertook to answer the objections urged against his discoveries as being in conflict with the Bible; but in the course of it he was unfortunate enough to make the assertion that the Scriptures had nothing whatever to do with scientific matters. He also undertook to explain the "standing still" of the sun at the command of Joshua from a scientific stand-point, showing that the theologians did not correctly understand the biblical narration; in doing which he became guilty of the heinous offence, being a mere layman, of undertaking to explain the Scriptures. Many of the pulpits opened their batteries on him, and denounced him as one who was teaching a doctrine calculated to bring the Holy Scriptures into contempt. Cardinal Bellarmine, the first

authority in the sacred college, in referring to the Copernican theories, "held their teachings to be heretical, and that the principle of the double motion of the earth was undoubtedly contrary to Holy Scripture." *

The letter of Galileo fell into the hands of some Dominicans, by treachery it is asserted, who were horrified at the idea of a layman's undertaking the task of interpreting the Holy Scriptures, and thereupon he was denounced to the Holy Office. There was much confusion over the matter, with the result that he was admonished by Cardinal Bellarmine; but he continued to uphold the Copernican theory with his usual vigor, and herein made a mistake. He should have bowed until the storm had passed; but he was too firm in his opinions, too blinded by his discoveries to see the storm which was rising on the horizon. Soon after he was "admonished" the congregation denounced the Copernican theory by which to teach it became a delicate and dangerous attempt.

In 1632, he issued the great work, *The Dialogue*, in which, in a conversation purporting to be held between several persons he developed all his theories in regard to the motion of the earth and the system as enunciated by Copernicus. Hardly had the distribution of the work been commenced when there came a positive order from the Inquisition to seize every copy in the booksellers' shops throughout all Italy. The publisher was ordered to discontinue the publication of the book, and to forward to Rome all the copies he had left. A Congregation was called; and at the age of seventy-five, Galileo, broken, and in ill health, was cited to appear before the Inquisition. He went, and during the year, had three examinations, the result being that he was declared to

* Karl Von Gebler.

be "vehemently suspected of heresy," and condemned to imprisonment during the pleasure of the Holy See. His penance was that he was ordered to repeat the Penitential Psalms once a week, for three years; and then, on his knees he was to recite the abjuration which had been prepared at the dictation of the pope, Urban VIII. At the same time, all the works of Galileo were placed in the *Index Expurgatorius.* On the 1st of April, 1634, an edict came from Rome which ordered that he should be practically separated from all personal contact with the world. He soon after became blind; and after a long period of intense suffering, he died on the 8th of January, 1642. There was a desire expressed to give him a grand funeral by his admirers, but they were dissuaded from doing it by reports from the Inquisition and the Vatican that such a course would be viewed with displeasure. There was for a time considerable discussion as to whether he had the right to make his will, and likewise as to whether his body should be permitted to rest in a consecrated ground. His will was finally allowed to be carried out, and his remains were entombed. He was buried in Santa Croce, in a chapel known as Del Noviziato, where it remained in obscurity for more than a century. And this was the end of one of the greatest geniuses whom the world has ever known.

The sentence of the Tribunal of the "Supreme Inquisition" which tried and convicted Galileo, on the 22nd day of June, 1633, contains the following: "We say, pronounce, sentence, and declare, that thou, the said Galileo, by the things deduced during the trial, and by thee confessed as above, hast rendered thyself vehemently suspected of heresy by this Holy Office; that is, of having believed and held a doctrine which is false, and contrary to the Holy Scriptures, to-wit:

That the sun is the centre of the universe, and that it does not move from east to west, and that the earth moves and is not the centre of the universe; and that an opinion may be held and defended as probable after having been declared and defined as contrary to the Holy Scripture; and in consequence, thou hast incurred all the penalties and censures of the Holy Canons, and other decrees both general and particular against such offenders imposed and promulgated. From the which, we are content that thou shouldst be absolved, if, first of all, with a sincere heart, and unfeigned faith, thou dost before us abjure, curse, and detest the above-mentioned errors and heresies, and any other error or heresy contrary to the Catholic Apostolic Roman Church, after the manner that we shall require of thee." This sentence was signed by several cardinals, who describe themselves "By the mercy of God, cardinals of the Holy Roman Church, Inquisitors of the Holy Apostolic See, in the whole Christian Republic especially deputed against heretical depravity."

The abjuration of Galileo is a document which deserves to be given a popular distribution, and is therefore herein given entire: "I, Galileo Galilei, son of the late Vincenzio Galilei, of Florence, aged seventy years, tried personally by this court, and kneeling before you, the most Eminent and Reverend Lord Cardinals, Inquisitors-generals throughout the Christian Republic against heretical depravity, having before my eyes the Most Holy Gospels, and laying on them my own hands; I swear that I have always believed, I believe now, and with God's help I will in future believe all which the Holy Catholic and Apostolic Church doth hold, preach, and teach. But since I, after having been admonished by this Holy Office entirely to abandon the false opinion that the sun was the centre of the universe and immovable,

and that the earth was not the centre of the same and that it moved, and that I was neither to hold, defend, nor teach in any manner whatever, either orally or in writing, the said false doctrine; and after having received a notification that the said doctrine is contrary to Holy Writ, I did write and cause to be printed a book in which I treat of the already-condemned doctrine, and bring forward arguments of much efficacy in its favor, without arriving at any solution: I have been vehement suspected of heresy, that is, of having held and believed that the Sun is the centre of the universe and immovable, and that the earth is not the centre of the same, and that it does move.

"Nevertheless, wishing to remove from the minds of your Eminences and all faithful Christians this vehement suspicion reasonably conceived against me, I abjure with a sincere heart, an unfeigned faith, I curse and detest the said errors and heresies, and generally all and every error and sect contrary to the Holy Catholic Church. And I swear that for the future I will neither say nor assert in speaking and writing such things as may bring upon me similar suspicion; and if I do know any heretic, or one suspected of heresy, I will denounce him to this Holy Office; or to the Inquisitor and Ordinary of the place in which I may be. And if I contravene any of these said promises, protests, or oaths (which God forbid!) I submit myself to all the pains and penalties which by the Sacred Canons and other Decrees general and particular are against such offenders imposed and promulgated. I, Galileo Galilei aforesaid, have abjured, sworn, and promised, and hold myself bound as above; and in token of the truth, with my own hand have subscribed to the present schedule of my abjuration, and have

recited it word by word. In Rome, at the Convent della Minerva, this 22nd of June, 1633.

"I, GALILEO GALILEI, have abjured as above,
"With my own hand."

It is a popular legend that Galileo, on rising from his knees said, in a low tone: "*Eppure si muove!*" ("It does move, though!") It is not at all probable that anything of the kind would have occurred without the remark being heard by some of the members of the court, in which case he would not have escaped severer punishment. It is something which he might have said; but which there is no reason for believing that he did say—at least at that time.

The admirers of Galileo must regard with unalloyed contempt his abjuration, as it cannot be said to be anything but rank perjury, unless it be assumed that at his age, and weakened by long illness, the death of his daughter, and various other inflictions, his mind may have become impaired as to the character of what he had taught, and the sacred nature of an oath. Some of his apologists have undertaken to teach that he did not in reality recant; that there are double meaning to some of the phrases of the abjuration, as for instance, that the sun does move, for he must have seen that the sun did move on its own axis: and that the earth is a centre, for he knew that it is a centre for certain bodies; but this would seem to be trivial. There is another theory held by some of the more orthodox of those who were engaged in his persecution, and that is that he did in reality disbelieve what he had for so many years taught; but even this is not probable. The more reasonable conclusion is that he was overcome by the difficulties of his situation, and that he abjured rather than incur the terrible fate which would have waited him at the hands of the Inquisition. It should be said here

that there is no reliable evidence to prove the often-urged charge that he was submitted to torture by the Inquisition; that is, of the rack and thumb-screw kind. In a sense, he was tortured by being dragged from his home while seriously ill to be present at his trial, and in being sentenced to the confinement of his own house, and forbidden to meet any of the outside world.

In justice to the then dominant religion, it should be added that the persecution which he endured was very far from being one in which the church acted as a unit. Urban VIII., before becoming pope, had met Galileo, had learned all the new theories in regard to the universe, had given them a quasi endorsement by treating Galileo with the greatest consideration. It was only after he had become pope that he changed his attitude, and assisted in the punishment which was inflicted on the victim. There were ten cardinals engaged in his trial, and of these only seven signed the condemnation. Many of the highest dignitaries of the church were among his warmest admirers, were believers in what he taught, and endeavored by every means in their power to prevent his arrest by the Inquisition, and to mitigate the severity of his punishment after condemnation. It is a very general belief that all the proceedings against him were inspired by the Jesuits, who, anterior to his discoveries, arrogated to themselves the possession of all the mysteries of science, and the right of its interpretation to the world.

Should the reader wish to look more closely into this question as to the torture of Galileo, there are abundant authorities.*

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* *Galileo and the Inquisition*, Madden. *Sur la Verité de Proces de Galileo*, Biot. *Galileo-Galilei, sa Vie, son Proces, et ses Cotemporains*, Philarete Chasles. *Galileo and the Roman Curia*, L. Von Gebler. *Life of Galileo, compiled principally from his correspondence and that of his*

It may be stated in closing this chapter of the great Italian discoverer that there has never been any very spirited attempt to defend the trial and condemnation by the church in power at the time, and which is held responsible for the act. In his defence Madden * says: "I do not believe it is incumbent on any Roman Catholic to attempt to justify the proceedings that were actually carried into effect against Galileo. The fullest consideration I have given this subject leaves a conviction on my mind that these proceedings were not expedient or productive of any temporary advantage or permanent utility to religion, civilization, science, or learning. I think it is to be lamented that they were adopted, however much they were provoked by Galileo." Such defence as he offers is to the effect that Galileo had broken faith with the Inquisition when he had been admonished by them that he must not promulgate the doctrines of Copernicus; that he was unwise in undertaking to show that the Scriptures, not being in accord with his discoveries, were not worthy of credence; and that the actions of the Inquisition are not those of the Romish Church. In fine, this writer admits that action would not have been taken against Galileo: "I know full well, they (the proceedings against Galileo) would not have been adopted against Galileo by the Pontiff, Urban VIII., if they had not been forced on him and the court of Rome by some members of religious orders, of zeal that was not regulated by prudence tempered by charity, and not directed by a policy that is 'wise unto salvation,' as well as bold and undeviating."

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daughter. Galilee, son Proces, sa Condamnation, by M. Henri de l' Epinois. *Psychological Inquiries,* by Sir Benjamin Brodie, Bart. *Histoire de l' Eglise*, by M. Bercastel. *Contributions to Italian History,* by Alfred Von Reumont. *Histoire des Sciences Mathematics en Italie,* by M. Libri, etc., etc. etc.

* *Galileo and the Inquisition.*

CHAPTER XI.

THE MICROSCOPE AND THE TELESCOPE.

THE microscope and the telescope are alike, and yet unlike. They are alike in that they penetrate distances which, before their invention, were unknown, and in opening up new worlds where, before, nothing of importance was supposed to exist. They are unlike in that one applies itself to the infinitely vast, and the other to the infinitely little. "Extremes meet." The telescope, directed upwards, reveals millions of great worlds doubtlessly inhabited; the other brings into view billions of infinitesimal worlds, each of which is thronged with uncountable myriads of existences. Both have extended beyond all comprehension the scope of man's vision; have shown him that creation includes vastly more than an earth in the middle, a sun to light it by day, and moon and stars to illuminate it by night; that life is more than man and a few animals, and that animate existence is everywhere through all the illimitable stars of the sky, the waters of the ocean, the tissues of the body, in the air, in the dust, in the pools, in vegetation, in the sod, in the marsh, in fine—everywhere. We find that the fecundity of nature is the most marvellous of her developments. All creation is a crowded tenement house—every room, every corner, every interstice filled to its utmost capacity. There are in this vast tenement house even tenants within tenants, so

great is the demand for room. There are existences which support within themselves other existences, and these again give within themselves sustenance to others.

As it is certain that beyond those starry worlds which the most powerful of telescopes have revealed, there are still other worlds, and beyond them still others illimitably, so in the opposite direction there are remoter existences which the utmost power of the microscope has not yet unveiled, and which, growing less in magnitude, may extend to infinity.

It requires no great stretch of imagination to construct some being, not divine, who is as much greater than we, as we are greater than the most minute of the existences which we have discovered by the aid of the microscope. Let us imagine this superior being an occupant of some central body of some one of the great stellar systems. To such an one all the surrounding stars would seem to be a solid crystal mass. He would believe himself in the centre of a vast and limitless ocean. This environment would appear to him as the ocean does to us, compact, each drop in contact with every other adjacent drop. Now, suppose that he should become the possessor of a microscope powerful in proportion to his stature. He brings it to bear on the circumjacent mass, and discovers that what he supposed to be a compact and dense body is really made of crystal drops which do not touch each. These drops are to us the stars which we know to be millions of miles apart; to this being they seem to have a slight separation. He examines further, and there is revealed to him some evidences of life. He may even be able to discover that some of these existences move in an upright position on two legs, and others on four legs. He concludes that one of these drops is inhabited. But how infinitely remote is he from discovering all the facts! He would

miss the small birds, the vermin, the insects, and the thousands of other lives that are visible to the unaided sight. How little would he suspect that beyond the extreme of his microscope there are to be found existences billions of times more numerous than those which he has seen! So with us. As there are limits beyond the power of the microscope of this great being—at which real existence, as to number, commences—so beyond the limits of our instruments it may be that the great majority of things that live are to be found. Who knows what would be revealed could investigation of the little commence where it ceases with us, and extend from this new point of departure as far in proportion as it now extends from us?

The telescope, and the microscope have revealed to us only the outskirts of the infinitely great and the infinitely little. The antipodean concept—if it may be so termed for the sake of the convenience of the expression—of space is the infinite divisibility of matter. There are worlds above us; there are others below us, and in the case of either of these directions, there may be no necessary limit to animate existence.

Let us look at this matter, for a moment, from the stand-point of the infinitely Little. Let us suppose that one of the million inhabitants in a drop of water becomes in some way possessed of an instrument which enables him to scan the distance as we do with the telescope. Before getting possession of such an instrument, he has always been of the belief that his drop of water is a complete world. Away in the vast distance he sees other minute bodies, which are really drops of water, but which to him are vast bodies from which he gets light and heat. He gets possession of the telescope, and his first discovery is that his drop of water is not the only world in existence; but that there are all about him

other worlds. He perhaps speculates as to their being inhabited; he sees these enormous worlds as far as the instrument can aid his eye to reach. In fact, he is forced to the conclusion that there are other worlds, although to him they are vast and inaccessible distances away. He lives but a second or two, and yet during that time he may make computations of the laws which govern his world, its relations to the others; for his second of existence to him is as long in proportion to his dimensions and his surroundings as our threescore years and ten are to the human race. He may have his cycles, his epochs, his æons. In short, it may be that there is a series of worlds extended from the one extreme to the other, and from the stand-point of an observer in each of them, there may be appear, in looking towards the little, only a compact mass, which to the actual inhabitant is, in each instance, the centre of some great system.

But the microscope has other uses than merely the creation of suggestions as to the deeper recesses of the minute. Its power may be estimated from an assertion that the minutest animalcule is 34,560,000,000,000,000,000 times smaller than a whale; that there are at least 100,000 species of animalcules.* We have been able to deduce from observations made by it that some animalcules propagate so rapidly that one of them in four days would produce over 70,000,000,000 of its species.† It also shows us that 300,000 of these animate bodies may inhabit a drop of water. A species of fungus (*bovista gigantea*) has been known to increase its size more than a million times during a single night. Having shown us these things which are both curious and instructive, the microscope has a utility part which is of the greatest

* Dick.

† Ehrenberg.

NEW NATIONAL MICROSCOPE.

importance in innumerable departments of labor, both scientific and practical. The world knew but comparatively little of the minuter composition of the human body until the microscope gave its potent assistance. To medicine, it has been of infinite service. It gave to the surgeon facts of the greatest value which he could nowhere else have obtained. Morbid structure placed under its powerful light affords information as to the causes of disease which could not otherwise be obtained. It is not very long since, a twelve-month, that the world was electrified by the discoveries of Pasteur in regard to a disease which was very fatal among sheep. The microscope was brought into use to solve the problem, when it was found that the disease was owing to a parasite; the discovery led to the cure. He weakened the parasitic virus by exposure, then innoculated the sheep with it, and the result was that the epidemic was arrested. Koch, a German savant, brought this instrument into use to locate the cause of pulmonary consumption. He found that the matter expectorated from the lungs of this class of consumptives contained an enormous number of minute parasites known as bacilli. A series of experiments is being conducted, after the principle of that of Pasteur, with the hope that, in time, by innoculation, this scourge of modern civilization will be mitigated, if not wholly obliterated. Its value is by no means confined to the demands of medicine and physiology. It has performed valuable service in the department of justice. In the celebrated Burdell murder trial which took place many years ago in New York, a very essential change was made in the condition of the accused by the microscope, which showed that some blood on the handrail of the stairway, and in other places, was not the blood of the victim, but catamenial in its origin. It has shown in other instances that what was supposed to be

blood on the knife of a person suspected of committing a murder, was merely rust.

In the detection of the adulteration of food and drugs, and other articles, the microscope has been invaluable. In the study of the physiology of vegetables, it enables an examination of the earliest processes of vegetable growth, and the parts which are played by the different tissues in the growth, and maturing of the plant. It shows the existence of poison in cases where the disclosures can be reached by no other agencies. "It tells the murderer that the blood which stains him is that of his brother, and not that of the other life he pretends to have taken; and as a witness against a criminal, it appealed to the very sand on which he trod at midnight."*

The microscope consists of the simple and the compound. The latter is a comparatively modern invention; the other, in one form and another can be traced back to the ancients. The original instrument must have been known to the Greeks and Romans, but in a very primitive form, and as little like the modern, as a watch is like a clepsydra. Aristophanes speaks of globules of glass that were sold in the shops; Cicero mentions a Homer's Iliad which was written on parchment which was contained in a nut-shell; and Pliny speaks of an elaborate work executed in ivory by a Milesian, which a fly could cover with its wings. These facts show that there must have been some artificial aid to the natural vision. The most simple form of the microscope is a glass which is flat on one side, and rounded out on the other (plano-convex), and which is placed in a small tube, blackened on the inside. These forms are valuable for a good deal of useful work, among which the examination of bank bills, signatures, and the like, are the

* Hogg.

best known and most common. These instruments with only one lens have been found in the ruins of Herculaneum, in those of Nineveh, the latter being undoubtedly used for optical purposes, and never as an article of dress.* But, however it may be as to the knowledge of the ancients, there is great difficulty in locating the invention of the original of the present microscope. The credit of having introduced it is usually given to Jansens, and who made it at least as early as 1590. About the same time a species of microscope was brought to England by the manufacturer, William Drebell. According to some authorities, it was like one lately described, and of which M. Aepinus said, "it was formed of a copper tube six feet long, and one inch in diameter, supported by three brass pillars in the shape of dolphins; these were fixed to a base of ebony, on which the objects to be viewed were placed." This was not a microscope of the kind now in use; but is surmised by some experts to have been a species of microscopic telescope. In 1665, it was discovered that globules of glass possess great magnifying power, and were applied to microscopes instead of the plano-convex lens. The method of using one of these primitive, or simple instruments is thus described: "If you are desirous of obtaining a microscope with but one single refraction, and consequently capable of procuring the greatest clearness and brightness, any one kind of a microscope is susceptible of, spread a little of the fluid you intend examining on a glass plate; bring this under one of the glass globules, then move it gently upwards till the fluid touches the globule, to which it will soon adhere, and that so firmly as to admit being moved a little backwards and forwards. By looking through the globule you will then have

* Sir David Brewster.

a perfect view of the animalcules in the drop." * In the middle of the seventeenth century, compound microscopes were constructed, and in 1736, the celebrated Lieberkuhn produced the solar microscope. Anterior to this, Newton, 1672, had submitted a design for a microscope by reflection. Following Lieberkuhn, there were rapid improvements in the microscope. Even to-day, the instrument is not believed to have reached the limits of its powers, although it has employed upon it some of the most ingenious and ambitious minds of the age. It is believed by some that the limit of its power is within sight; but even its present prodigious capacity may advance to an unforeseen extent.

Some of the most curious of the developments of the microscope have been made in the examination of the structure, habits, and life of the minute animals known as infusoria. "The astronomer turns his telescope from the earth, and ranges over the vast vault of heaven, to detect and delineate the beautiful objects of his pursuit. The naturalist turns his microscope to the earth, and in a drop of water finds a wondrous world of animated beings, more numerous than the stars of the Milky Way. . . The infusoria are a mighty family, as they frequently, in countless myriads, cover leagues of the ocean, and give to it a tinge from their beautiful hue. They are discovered in all climes, having been found alive sixty feet below the surface of the earth, and in the mud brought up from a depth of sixteen hundred feet of the ocean. They exist at the poles and the equator, in the fluids of the animal body and plants, and in the most powerful acids. A brotherhood will be found in a little transparent shell, to which a drop of water is a world; and within these are sometimes other communities,

* Dr. Hooke.

performing all the functions granted them by their Creator, and eagerly pursuing the chase of those less than themselves. The forms of the infusoria are endless; some changing their shape at pleasure, others resembling globes, eels, trumpets, boats, stars, pitchers, wheels, flasks, cups, funnels, fans, fruits.

"The infusoria have no night in their existence; they issue into life in a state of activity, and continue to the duration of their being in one ceaseless state of motion; their term is short, they have no time for rest, and therefore have but one day which ends in their death and decomposition. Nevertheless, they appear to love that which promotes life—the light of heaven; but when others, born in the bowels of the earth, and who never partook of the blessing, like the ignorant among mankind, they have their own round of unenlightened joys, perform their mechanical duties, and expire hidden and unknown." *

One of the most curious of the minute animals which have been examined, is the polype. It looks, at a cursory glance, like a hair. It is a glutton which stops at nothing to gratify its voracious appetite. It is a robber, which fears nothing, and will attack anything which gives it promise of food. It has long tentacles, which it can extend and contract, and which it uses to feel for its prey, and with which to lasso the prey when within reach. "Sometimes it happens," says Dr. Johnson, "that two polypes will seize upon the same worm, when a struggle for the prey ensues, in which the strongest gains, of course, the victory; or each polype begins quietly to swallow his portion, and continues to gulp down his half, until the mouths of the pair near, and come at length into

* *The Microscope*, by Hogg.

actual contact. The rest that now ensues appears to prove that they are sensible of their untoward position, from which they are frequently liberated by the opportune break of the worm, when each obtains his share; but should the prey prove too tough, woe to the unready! the more resolute dilates the mouth to the requisite extent and deliberately swallows his opponent; sometimes partially, so as, however, to compel the discharge of the bait, while at other times, the entire polype is engulphed! But a polype is no fitting food for a polype, and his capacity for endurance saves him from a living tomb; for, after a time, when the worm is sucked out of him, the sufferer is disgorged with no other loss than his dinner."

Another curious feature of this polype has been brought to light by the microscope. If one of them be cut in two, the fore-part, which contains the head, and mouth and arms, lengthens itself, creeps, and eats on the same day. The tail forms a head and mouth at the wounded end, and shoots forth arms more or less speedily, as the heat is favorable. If the polype be cut the long way through the head, stomach, and body, each part is half a pipe, with half a head, half a mouth, and some of the arms at one of its ends. The edges of these half pipes gradually round themselves and unite, beginning at the tail end; and the half mouth and half stomach of each becomes complete. A polype has been cut lengthways at seven in the morning, and in eight hours afterwards, each part had devoured a worm as long as itself. Still more wonderful is the fact that, if turned inside out, the parts at once accommodate themselves to their new condition, and carry on all their functions as before the accident. Indeed, this animal seems so peculiarly endowed with the germs of vitality in every part of its body, that it may be cut in ten

pieces, and every one will become a new, perfect, living animal." *

Startling and incredible as the assertion may appear to some, it is none the less the fact, established beyond all question by the microscope, that some of our most gigantic mountain ranges, such as the mighty Andes, towering into space twenty-five thousand, two hundred and fifty feet above the level of the sea, their base occupying so vast an area of land; as also our massive limestone rocks, the sand that covers our boundless deserts, and the soil of many of our widely-extended plains, are principally composed of invisible animalcules. The stratum of slate, fourteen feet thick, found at Bilin, in Austria, was the first that was discovered to consist almost entirely of minute flinty shells. A cubic inch does not weigh quite half an ounce, and in this bulk it is estimated that there are not less than forty thousand millions of individual organic remains.† It is stated by Dr. Buckland that "the remains of such minute animals have added much more to the mass of materials which compose the exterior crust of the globe than the bones of elephants, hippopotami, and whales."

The uses of these infusoria are more than merely to build up the solid crusts of the earth. They have still another mission that is essential in the system of creation. "Consider their incredible numbers, their universal distribution, their insatiable voracity; and that it is the particles of decaying vegetable and animal bodies which they are appointed to devour and assimilate. Surely we must, in some degree, be indebted to these ever-active, invisible scavengers, for the salubrity of the atmosphere, and the purity of the water. Nor is this

* M. Trembly.

† *The Microscope.* Hogg.

all; they perform a still more important office in preventing the gradual diminution of the present amount of organized matter on the earth. For, when this matter is dissolved or suspended in water, in that state of comminution and decay which immediately precedes its final decomposition into the elementary gases, and its consequent return from the organic to the inorganic world, these wakeful members of nature's invisible police are everywhere ready to arrest the fugitive organized particles, and turn them back into the ascending stream of animal life. Having converted the dead and decomposing particles into their own living tissues, they themselves become the food of the larger infusoria, and of numerous other small animals, which in their turn are devoured by larger animals; and thus a food fit for the nourishment of the higher organized beings is brought back, by a short route, from the extremity of the realms of organized matter. These invisible animalcules may be compared, in the great organic world, to the minute capillaries in the microcosm of the animal body; receiving organic matter in its minutest subdivision, and when in full career to escape from the organic system, turning it back by a new route, towards the central and the highest point of that system." *

The microscope revealed to us a world concerning which there had been little difference of opinion, and not much thought anterior to its invention. Far otherwise is it with the telescope. It came to unsettle theories which had existed for centuries, to scatter beliefs that had become indurated by ages of use, to correct and develop half-formed guesses, to revolutionize the astronomical accretions of thousands of years. It was no slight task, as has been shown in the references

* Professor Owen.

to Galileo; but what he encountered was but a small part of the labor to be performed, the errors to be corrected, the calculations to be made, before the world obtained even a glimpse of the stellar and planetary systems as we know them to-day. It will serve to heighten the value of the invention of the telescope, and to increase the renown of its potent resources, and results accomplished, if one takes a glance over what it had to encounter in the shape of the theories which had been built anterior to its appearance on the field.

During all ancient ages the earth was a flat surface on which rested a great firmament, concave on the side towards the earth, and a plane on the upper side. The sun, moon, and stars were the attendants of this majestic body, the earth. They were created solely to minister to its needs, to afford it heat and light during the day, and light through the night. The sun was a combination furnace and lamp; the moon and stars, a larger lamp, and some smaller ones, whose sole duty it was to light up the vaults during the absence of the sun. What wonder that these ancient men believed themselves a great people to be the centre of such a grand system constructed expressly for their benefit! And how intense was the humiliation of the race when it was demonstrated that the earth, in place of being the centre of a system with sun, and moon, and myriads of stars shining expressly for their delectation, was simply one of the very least of all the bodies which filled the heavens! Fancy some man who supposes that he is king of a great country, to suddenly discover that he is the very least among all the thousands over whom he claimed to exercise imperial powers! Is it any wonder that the teachings of Copernicus excited derision; that the investigations of Galileo and others drove men to distraction? It was a terrible downfall for the race; hurled from the

very pinnacle of the universe to find themselves mere parasites crawling over a contemptible body, the most insignificant of even the least of those whom they had supposed to be their slaves.

But science was inexorable. The earth fell from its high estate. It became the very least of those among whom, for centuries, it had stridden as a superior. The lamps in the heavens were extinguished; they no more shone for the illumination of the poor little earth. If there were inhabitants on these shining heights, it was certain almost that they had never even noticed the earth crawling through space in its annual revolution around the sun. As little might the mighty emperor of Rome know of the whereabouts and character of some insignificant serf, living in the solitude of some vast forest in some remote portion of his dominions. Who would not struggle against being precipitated from such a height to such depths? The fall of the haughty Lucifer from the topmost battlements of the Celestial City into the fathomless depths of the infernal regions was no greater than that of mankind, when the earth was suddenly changed from the principal in the universe to a miserable satellite; and crawled along obscure and unknown on a highway where for ages it had fancied itself the grandest among all the heavenly hosts.

Some of the beliefs which preceded the discoveries of Copernicus were sufficiently curious to deserve mention. Some of the earlier theories were that the earth rested on water; others had it that it rested on nothing in particular; some taught that it was supported on columns; among the Hindoos the theory was that the earth was a hemisphere whose flat sides rested on the backs of four elephants, they in turn on the back of a tortoise, and this floated on the surface of a boundless ocean. Many of the ancient Greeks thought it rested on the top of a

great cylinder; some of them held to the opinion that it was cubical with the countries on the upper surface of the cube; still others thought it was an immense inclined plane which extended to infinity in every direction. In the mythology of the Greeks, the earth was flat, there was a solid vault above in which the stars represented various things, and were carried in their course by chariots. There was an inhabitable heaven above, and a Tarturus beneath.

The ideas of the earth which obtained among the nations after the fall of the Roman empire were not very much of an improvement over those which prevailed among the pagans. In the fourth century, several noted lights gave adhesion to the flat earth, with a firmament above, among whom was Diodorus, bishop of Tarsus; and another dignitary, Severianus, bishop of Gabala, compared the world to a house in which the earth is the ground floor, the lower heavens the ceiling, and the upper, or heaven of heavens, the roof. This double heaven was also admitted by Eusebius of Cæsaræ.* Cosmas, in the sixth century, wrote a book to prove that the assumed sphericity of the earth, as dimly suggested to those who noticed that, during an eclipse, the shadow cast by the earth was round, was against the Bible, and the teachings of the church. He constructed a map of the earth which showed that it is a parallelogram, twice as long as its breadth. On all sides are oceans, and beyond these oceans is another continent which was inhabited by man before the deluge. On the outsides of the earth are four great walls, which rise to a great height and which are rounded off at the top in a dome. Men lived in the box thus formed; and above the dome were the heavens in which the higher spirits find their

* *Astronomical Myths.* Blake.

habitation. He modeled this queer world after the form of the tabernacle that Moses built. The movement of the sun and stars he explained by asserting that it was done by angels, some of whom attended to the sun, others to the motions of the moon, and some to the duty of collecting clouds and seeing that the supply of rain was attended to. It was not an uncommon idea, in those days that the business of steering the stars along their routes was entrusted to angels, some carrying them on their shoulders, "like the *omophores* of the Manicheeans; others that they rolled them in front of them or drew them behind; while the Jesuit Riccioli, who made astronomical observations, remarks that each angel that pushes a star takes great care to observe what the others are doing, so that the relative distances between the stars may always remain what they ought to be." *

Another cosmographer was the famous Venerable Bede, whom all the world has heard of, and who is regarded as one of the most learned men of his times. He announced that the earth is an element placed in the middle of the world, as the yolk is in the middle of the egg; around it is the water, like the white surrounding the yolk; outside this is the air, like the membrane of the egg; and round all is the fire which closes it in as the shell does. The earth being thus in the centre, receives every weight upon itself, and though by nature it is cold and dry in its different parts, it acquires accidentally different qualities; for the portion which is exposed to the torrid action of the air, is burnt by the sun, and is uninhabitable; its two extremities are too cold to be inhabited, but the portion which lies in the temperate region of the atmosphere is habitable. The ocean which

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* *History of the Heavens.*

surrounds it by its waves as far as the horizon, divides it into two parts, the upper of which is inhabited by us, while the lower is inhabited by our antipodes; although not one of them can come to us, nor one of us to them. There were other theories in which the earth was also an egg with the lower half of it plunged in water; one in which the earth was shaped like a wheel and placed in the middle of the universe, being surrounded by the ocean; * another in which, in the ninth century, represents the earth as a round flat, or planosphere; and so on to an almost illimitable extent down as late as the fifteenth century.

If the telescope had all this mass of misconception, backed by a large element of bigotry, to encounter, with reference to the earth, it had no less than this to meet in the prevailing ideas in regard to the heavens. Originally, the ancients were believers in a solid sky; and then came change in thought, in which it was a matter of much disputation whether it was solid, gaseous, or a liquid. It was believed by many of the eminent sages and philosophers that the stars were fixed in this solid sphere, and that stars and sphere all revolved as one, the motion engendering heat, which was communicated to the earth below. As a rule, the church, for many centuries after the fall of the Roman empire, held to the opinion of not merely one, but many solid spheres, one within the other; the number, at one time having reached as many sixty-seven. It was taught by Xenophanes, 360 B. C., that the stars were lighted every night and extinguished every morning; that the sun is a fiery cloud; that eclipses take place from the sun being extinguished, and then re-lighted; that the moon is inhabited, but is eighteen times larger than the earth;

* *De Universo*. Raban Maur.

that there are several suns and moons for giving light to different countries. *

Of all the ancient systems, the Ptolemaic is the most noted. In this system, according to Cicero, the "universe is composed of nine circles, or rather of nine moving globes each within the others, the outermost sphere of which surrounds all others, and on which are the fixed stars. Beneath and within this revolves seven other globes, moving in a direction contrary to that of the outer one, or the heavens. On the first circle revolves the star which men call Saturn: on the second Jupiter shines, that beneficent and propitious star to human eyes; then follows Mars, ruddy and awful. Below and occupying the middle region revolves the sun—the chief, prince, and moderator of the other stars—the soul of the world, whose immense globe spreads its light through space. After him come, like two companions, Venus and Mercury. Lastly, the lowest globe is occupied by the moon, which borrows its light from the star of day. Below this last circle, there is nothing but what is mortal and corruptible except the souls given by a beneficent Divinity to the race of men. Above the moon, all is eternal. The earth, situated in the centre of the world, and separated from heaven on all sides, forms the ninth sphere; it remains immovable, and all heavy bodies are drawn to it by their own weight." The earth itself, in this system composed of land and water, is a globe, and has two envelopes, one of air, next to it, and one of fire which is separated by a short space from the environment of air. Each of the globes above, or outside of the earth, is a heaven, named after the star, such as the heaven of the moon, the heaven of the sun, the heaven of Mercury. Outside of Saturn was the heaven

* *History of the Heavens.* Blake.

of the firmament, filled with the remoter fixed stars, and enveloping this, the crystalline heavens, or the abode of the blessed. By some of the Fathers, who from time to time worked over the system of Ptolemy, in order to meet constantly accruing difficulties, hell was placed in the middle of the earth, thus making it the very centre of the universe.

There might be mentioned scores of other systems in relation to the heavens and the earth; but nothing would be gained by it. Enough has been given to satisfy curiosity, and to show how wide the ancients, as a rule, were from divining the real conditions of the astronomical situation.

It was not till the early part of the sixteenth century that there was anything like a satisfactory solution of the problem which, for so many ages, had puzzled mankind. Nikolaus Copernicus was born in Thorn, Prussia, February 19th, 1473; and soon after, in 1503, he announced to the world his theory of the location, and movements of the earth, the sun, the planets, and the stars. He came to the conclusion that the sun and stars are stationary; that the moon revolves about the earth; that the earth and other planets revolve about the sun; and that the apparent movement of the heavens is caused by the revolution of the earth on its own axis. He gave years of study to this theory, and finally developed it in six books, *De Orbium Cœlestium Revolutionibus*, in 1543, the first copy of which was handed him as he lay on his death-bed, and on the very day that he died. He did not claim that he was the originator of the suggestion that the world moves; on the contary, he acknowledged that the idea had been presented before. Despite this, he was the first which gave to the world a rational and coherent system, and to him belongs the credit of the discovery. He was far from the truth in

what he did discover, for he had no idea of the elliptical character of the orbits of the planets; and he accounted for the changes in the seasons by a third motion in the earth, which was corrected by Kepler, in 1609, by his discovery of the ellipticity of the orbit of Mars.

It was while the astronomical world was in this condition that the invention of the telescope enabled the detection of the false, and the confirmation of the true in the discoveries of Copernicus and Kepler. As to the origin of this instrument, there is a great variety of opinion. That Galileo heard of such a thing, and produced one without ever having seen one seems to be established. But there is somewhat of a history in connection with the origin of the telescope which is worth mentioning.

The story of the origin, in which a boy plays the part of an accidental discoverer, is located in Middleburg, Zealand, at the shop of an optician named Jean Lippershy, in the year 1606. His little boy happened to be playing with some lenses, and in the course of it, looked through them, holding one before the other, and in doing this, he noticed that a distant clock appeared much nearer than usual; he called his father's attention to it, and who followed the matter up by making a draw tube, and on which he applied to the Holland authorities for a patent. He was refused on the ground that only one eye could be used in looking through it. It is from Lippershy's invention that Galileo obtained his idea of the telescope, and from which he constructed and improved the one with which he made his astronomical observations. A passage in Strabo, in chapter 138, strongly proves, despite the denials of modern science, the existence of the telescopes among the ancients.*

* Quant aux longues-vues, un passage du livre de Strabon, Chap. CXXXVIII., pourraint bien, malgre les denegations de la science moderne, en prouver definitivement l' existence chez les anciens. Fournier.

In 1611, Kepler improved the astronomical telescope by the introduction of two concave glasses. With his telescope, Galileo succeeded in reaching a magnifying power of thirty, by which he discovered the phases of Venus, the spots on the sun, the satellites of Jupiter, and the mountains of the moon. By the improvements of Huyghens, the magnifying power was increased to ninety-two, by which he was enabled to discover the the ring of Saturn, and one of his satellites. Cassini, of the Paris Observatoire, brought the magnifying power to one hundred and fifty, in about 1665, and was the discoverer of the rotation of Jupiter at the same period. The earliest telescopes which were reflectors were made by Gregory, in 1663, and by Newton, in 1672. Among the largest now in use are that of Herschel, which magnifies three thousand times; and Lord Ross', which magnifies six thousand times; one at Melbourne, seven thousand, and one at Marseilles, four thousand.* Washington and Chicago have each an instrument which take high rank among the noted telescopes of the world.

After this brief outline of the telescope, it is hardly necessary to ask if it has been influential in the development of civilization? If civilization, in its higher sense, be the expansion of knowledge, the increase of information, the breaking up of ignorance and superstition, the immeasurable enlargement of the horizon of information, then, indeed, has the telescope been a potent agency in the labor of aiding in the civilizing of the human race. It has been the iconoclast, than which the world has rarely, if ever, known one more destructive, or which has carried such wholesale devastation among the stupid, and unworthy fetiches and idols of the past.

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* Flammarion.

EQUATORIAL TELESCOPE OF WARNER OBSERVATORY ROCHESTER, N. Y.

It shattered with a single blow the crystal spheres which so snugly and so long ensconced the earth, like a cocoon that envelops the silk-worm. It took the earth from this fragile centre, redistributed the planetary worlds, brought the mighty sun to the central point, and sent the earth spinning far out in space, the very least of all those over whom it once, and for so many thousands of years, arrogated an insolent supremacy.

Nor is this all. It revolutionized the prevailing belief that a few men living on the borders of the Mediterranean constituted all of created intelligence; that the Supreme Ruler had no higher mission than to watch over this little area, and assign His angels to rolling the stars across the skies to give these few people light, while other angels fed the fires of the sun to keep its flames aglow. In lieu of all this, it has come to them, and all the world, that creation is endless; that there are no limits to the number and extent of worlds; that in remote as well as near space there are systems, planetary and stellar, compared with which ours, in magnitude, is as the flame of a feeble match to the conflagration of a continent. The Great First Cause, in whatever shape it may be regarded, is shown to be no mere local potentate, with half a continent as his kingdom, and his sole charge; but one which cares for and superintends all immensity. If nothing more had been done than to destroy this small idea of the Creator it would have played a most essential part in the drama of creation. Thanks to the telescope, and the spectroscope, it has been permitted the thinkers of the age to conclude that this is not the only inhabitable world; but that many of the planets, and all the members of the unlimited starry systems, have their inhabitants; people who live, love, die; who have perhaps their Petrarchs, their Lauras; their Alexanders and their Napoleons;

their Copernicuses, their Keplers, and their Newtons; who have statesmen, poets, philanthropists; who have graves at which they weep, and bedsides at which farewells are spoken, and last glances taken through streaming eyes; who have their philosophies of the future, their little or grand universes; who have in fact, all or many, of the qualities characteristic of the races who inhabit the earth. This globe on which we live is full of inequalities. The extremities are everlastingly clad in ice. Through its equatorial regions there prevails an unvarying heat, in which there gather the deadliest of miasms, in which disease lurks in slime and ooze and in decaying vegetation. Wild animals, the fiercest, deadliest; reptiles, loathsome, noxious—mortal in their wounds inflicted on man or beast; plants that exude poison; days that scorch like a thrice-heated furnace, and nights that chill the marrow—these are what are offered us by the tropical areas. There are here and there some pleasant regions; but few in comparison to those that are hateful.

Now, by way of contrast, look for a moment at Jupiter: "Jupiter is a world apart, privileged above all others; it has but a single season, and one which is unvarying during its slow, annual journey around the sun. The day and night there are of equal length; unchangeable climates rule in each latitude, extending in a harmonious, descending reach from the equator to the poles. The seasons of this magnificent Jupiter last twelve times as long as with us; they are shaded by insensible differences that are never rigorous or undesirable. It is the realized type of the world which has been dreamed of from all time; it is a world so superior that the earth will never attain even the most remote of its perfections. This planetary giant seems to have been placed in the heavens as a perpetual mockery of

the feeble efforts of man, and of his unhappy environment; or, better, I may say, as a symbol of hope which should stimulate men in their search for science and the good, and enable them to catch glimpses of the stately tableaux of a long and fruitful existence." *

It has been said by Brewster: "Upon a planet grander than ours, may there not exist a type of intelligence of which the most feeble may yet be superior to that of Newton? Have not its inhabitants provided themselves with telescopes more penetrating, and microscopes more powerful than ours? Have they not some process of induction more subtile, some means of analysis more fecund, and combinations more profound? There, have they not resolved the problem of the triune-unity, explained the enigma of luminiferous ether, and embodied the transcendent force of the soul, in the definitions, the axioms, and the theorems of geometry? These men possess, without doubt, a lofty and puissant power of reasoning which conducts them to a more healthy, and a more perfect knowledge of the designs, and the works of Deity. But, whatever may be their intellectual occupations, who can doubt that they study and develop the laws of matter, which are in action about them, above them, and beneath them?" †

Not the least of the wonderful things which have been revealed to us by the telescope is the awful distances of some of the fixed stars. The very nearest to us, a star in the constellation of Centaur, is not less than twenty trillions of miles; and a ray of light, in passing from this star to the earth, requires not less than three years. It requires twenty years for light to pass from one of the second magnitude to the earth; and one

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* *Physiologie des Etres.* Flammarion.

† *More Worlds than Ours.*

hundred and eighty years for one of the seventh. In the case of a star of the twelfth magnitude, not less than *four thousand years* are required for its light to reach the earth; and it will emphasize this statement when it is recollected that light travels at the rate of over two hundred thousand miles a second. What an incredible distance! It follows from this, that a star of the magnitude referred to might become extinct, and yet the earth would not know the fact until the lapse of forty centuries; or a star at that distance might come into existence, and the earth would not learn of it till four thousand years after the creation. Upon this state of things is based a very novel, and most striking series of conclusions. There is in existence a small publication,* in which these conclusions, and their data are given, and which are so curious, and the volume so little known, that some extracts will be given from it at this point. After having given the velocity of light, and the time required for it to travel between various points, the writer says: "From what we have already said, viz.: that the ray of light meeting our eye is not sent forth from the star at the same moment, but arrives here according to the corresponding and requisite number of seconds, minutes, or years, it follows that we do not see the star as it is, but as it was at the time when the ray of light was emitted.

"Thus, we see the star in Centaur as it was three years ago, Vega as it was twelve years ago, and so on to the star of the twelfth magnitude, which we look upon as it shone four thousand years ago. Hence follows the conclusion, which has frequently been made by astronomers, and which in its result has become popular, viz., that a star of the twelfth magnitude may have been

* *The Stars and the Earth.* Anonymous.

extinguished, four thousand years ago, whilst we, nevertheless continue to see its light shining.

"This conclusion, when applied to each of the former positions, gives the following results. We do not see the moon as it is, but as it was a second and a quarter before, *i. e.*, the moon may have already been dispersed into atoms for more than a second and we should still see it entire and perfect. We do not see the sun as it now is, but as it was eight minutes before; Jupiter as it was forty-two minutes; Uranus as it was more than two hours before; the star in Centaur as it was three years ago; Vega as it was nine and a quarter years; and a star of the twelfth magnitude as it was four thousand years ago. These propositions are well known, and have already been published in popular works on astronomy.

"It is really marvelous that nobody has thought of reversing them, and of drawing the very remarkable and astonishing conclusions which pour in on us in a full stream from the converse, and the inferences which may thence be drawn. The following is the relative view of the matter: As we have before remarked, we see the disk of the moon, not in the form which it now is, but as it was five-quarters of a second before the time of observation.

"In exactly the same way, an imaginary observer in the moon would not see the earth as it was at the moment of observation, but as it was five-quarters of a second before. An observer from the sun sees the earth as it was eight minutes before. From Uranus the time between the reality and the perception by the eye being two hours and a half apart—if, for example, the summit of the Alps on a certain morning was illumined by the first rays of the sun at six o'clock, an observer in the planet, who was provided either with the requisite power

of vision or a sufficiently good telescope, would see this rising at half-past eight of our time.

"An observer in Centaur can, of course, never see the northern hemisphere of the earth, because this constellation never rises above our horizon. But supposing it possible, and that an observer were standing in this star with such powerful vision as to be able to distinguish all particulars upon our little earth, shining but feebly luminous in its borrowed light, he would see, in the year 1843, the public illuminations which, in the year 1840, made the cities of our native land shine with the brightness of the day during the darkness of the night. An observer in Vega would see what happened with us twelve years ago, and so on, until an inhabitant of a star of the twelfth magnitude, if we imagine him with unlimited power of vision contemplating the earth, sees it as it was four thousand years ago, when Memphis was founded, and the patriarch Abraham wandered on its surface.

"In the immeasurably great number of fixed stars which are scattered about the universe, floating in ether at a distance of between fifteen and twenty billions of miles from us, reckoning backwards any given number of years, doubtless a star could be found which sees the past epochs of our earth as if existing now, or so nearly corresponding to the time, that the observer need wait no long time to see its condition at the required moment.

"Supposing it to be possible that a man could move from point to point without any employment of time, and provided with a telescope which would penetrate any distance and render all things visible, it would be entirely possible to recall every event in history, and to look on it at the very moment of its occurrence. If, for instance, we wished to recall Luther, and see him before the council of Worms, we must transport ourselves

in a second, to a fixed star, from which the light requires about three hundred years (or so much more or less) in order to reach the earth. Thence the earth will appear in the same state, and with the same persons moving on it, as it actually was at the time of the Reformation.

"The pictures of all secret deeds which have ever been transacted, remain indissolubly and indelibly for ever, reaching from one sun beyond another. Not only on the floor of the chamber is the blood-spot of murder indelibly fixed, but the deed glances further and further into the spacious heaven.

"At this moment is seen, in one of the stars, the image of the cradle from which Caspar Hauser was taken to be enclosed in a living tomb for so many years; in another star glances the flash of the shot which killed Charles XII.

"Let us imagine an observer, with infinite powers of vision, in a star of the twelfth magnitude. He would see the earth at this moment as it was in the time of Abraham. Let us moreover, imagine him moved forward in the direction of the earth, with such speed that in a short time (say in an hour) he comes to within the distance of a hundred millions of miles, being then as near to us as the sun is, whence the earth was seen as it was eight minutes before; let us imagine all this, and then we have the following result: that before the eye of this observer the entire history of the world, from the time of Abraham to the present day, passes by in the space of an hour, . . and if we give the observer time to halt at pleasure in his path, as he is flying through the ether, he will be able to represent to himself, as rapidly as he pleases, that moment in the world's history which he wishes to observe at leisure, provided he remains at a distance when this moment of history

appears to have just arrived; allowing for the time which the light consumes in traveling to the position of the observer."

If one can imagine a condition, after having become disembodied, in which the spirit can move at will, from point to point in space, without the element of time, then may the spirit, by transporting itself to the proper distance from the star to be viewed, see at once, not only on this planet, but on every other planet, and every other star in space, any particular event in its career.

How much that passes for history, in this world, would become verified by the application of this test?

CHAPTER XII.

DESCARTES, KEPLER, NEWTON, ETC.

RENÉ DESCARTES was more of a philosopher than a discoverer or an inventor, in the usual acceptation of the words. He was born in Touraine, France, March 31, 1596, and died in Stockholm, February 11, 1650. He received a liberal education, traveled a good deal, and served in the Dutch army under Maurice of Nassau, and later, served as a volunteer, in 1619–20, under Maximilian of Bavaria, and was present at the battle of Prague. In 1637, he published his first book,* in which were treatises on method, on dioptrics, on meteors, and geometry. He followed these with other publications. His philosophical speculations play no part in a work of this kind; and may be dismissed with the statement that he created a new system of philosophy which occupied a conspicuous position for more than a hundred years, and is still not without influence, its cardinal point being the supremacy of evidence and reason in solving cases of doubt.

Among his discoveries, or alleged discoveries, was that known as the theory of vortices, by which he undertook to explain why celestial bodies are held in their places; but Newton soon after supplanted it by the production of the theory of gravitation. He made some

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* *Discours de la Methode.*

very important discoveries as to the application of algebra to geometry; and gave a good deal of attention to that branch of optics, known as dioptrics, and which treats of the reflection of light, and to hydrostatics. "The actual relation, known as the 'law of sines,' was discovered by Willebrord Snell, about the year 1621. Descartes, who unjustly claimed this discovery, has really the merit of having applied it so as to explain the general formation and the angles of the rainbow." *

Johann Kepler was born in Wurtemberg, 1571, and died November 15, 1630. He received an excellent education, and devoted himself to optics at the beginning of his career. His father was a nobleman, but had become reduced, and kept an inn, his son during his youth officiating as a servant before he entered the monastic school of Maulbronn, and after this studied astronomy under one of the pupils of Copernicus. He made some discoveries in optics which would have given him a permanent reputation, had it not been that he followed them with others of such transcendent importance that his work on dioptrics sinks into insignificance. Up to the time that he discovered otherwise, it was the opinion of those who adopted the lately-discovered theories of Copernicus, that the planets moved about the sun in a circular orbit. After long and repeated efforts, he discovered the ellipticity of Mars; and he further discovered that a line connecting the sun and the planet (*radius vector*) describes equal areas in equal times; and some years later, he discovered that the squares of the periodic times of the planets are proportional to the cubes of their mean distances from the sun. These are known as the three laws of Kepler; the last was discovered in May, 1618, and was regarded by Kepler as the

* *Am. Cyclopædia.*

chief of all his labors. This third discovery cost him nearly twenty years of the severest of study, although its value to astronomy is such that it would have been worth a thousand times as much labor to attain it. It is said of him that he published a book containing the last-named discovery, and said: "It may well wait a century for a reader, as God has waited six thousand for an observer." He invented the gauge, owing it is said, to the fact that he believed that the wine which was furnished for his wedding was not of the quality represented. About 1620, he published the seven books comprising his *Epitome of the Copernican Astronomy*, and which was very promptly prohibited by the Inquisition. Later, 1627, he published the *Rudolphine Tables*, which are so remarkable a monument of patience and industry, that had Kepler done nothing more than compute them, he would be regarded as a benefactor of science. His discoveries are all of the most original and valuable character, so much so that he occupies a place in the very front rank of the scientific discoverers of modern years. He was constantly in debt; he had much to harass him in his domestic life, and in other directions; but despite all these, he gave to the world thirty-three works, in addition to twenty-two which he left in manuscript, and a volume of his correspondence.

Following Kepler, and preceding Newton, was Christian Huygens, who was born at the Hague, in April, 1629, and died there July, 1695. He came of a good family, and received a liberal education. He early turned his attention to telescopes, and in 1655, he produced one with a focal length of ten feet, the most powerful then known, and with it discovered what is now known as the fourth satellite of Saturn. He next gave considerable attention to theoretical mathematics, and produced some new calculations and discoveries in this line; but

later he gave his attention to more practical matters. It is said that, in order to count the beats of an isochronous pendulum, he invented the clock; which is something which would be very naturally the exact opposite of the conclusion of one who knows nothing of the facts, as it would naturally be concluded that the pendulum was invented to regulate the movement of the clock, and not the clock to merely record the movements of the pendulum. In 1659, he constructed a telescope with a focal length of twenty-two feet, and two eye pieces, with which he discovered a ring of Saturn. He also discovered the bands on the disks of Jupiter and Mars. In 1673, he invented the spiral spring used in watches, although there are two other claimants, Hooke, of England, and Hautefeuille of France. He published a treatise on light, a very famous paper, and one on gravity, whose cause he attempts to explain by supposing that ethereal matter revolves about the earth with a velocity greater than that of the planet, and compares it to the "force which causes bodies a little heavier than water, and lying lightly upon the smooth bottom of a cylindrical vessel containing water, to move towards the centre when the circular motion of the vessel by which its fluid contents have caused to revolve is arrested." He did not solve the problem, nor has any other thinker from that day to this been able to explain why bodies fall toward the earth instead of falling from it. He is credited with having made the first chronometers which were carried on ships.

As to the rank which he occupied, as an astronomer and a mathematician, he must be credited with a lofty position. He was regarded as the first astronomer of his period, and second to none in his mathematical researches, and their results.

The grandest figure of the seventeenth century, one

whose noble dimensions are not corroded, nor dwarfed by time, was Sir Issac Newton, who was born at Woolsthorpe, county of Lincoln, England, December 25, 1642. His father was a farmer, who died before the birth of his son. There was nothing auspicious about his advent into life; he was a posthumous child, prematurely born, and so diminutive and feeble that he was not expected to live. He is said to have been a very idle student, when first sent to school, standing low in his class; and was only finally induced to study for the purpose of passing a boy who stood higher than he, and whom he had worsted in a fisticuff encounter. Although he made this advance in this instance, he seemed more in love with mechanical objects than with the school curriculum. While a school-boy, he was incessantly engaged in the invention of mechanical contrivances, and in the imitation of those already known. He thus made a windmill, a water-clock, and a sort of a bicycle to be moved by the person who rode it. He constructed also various other little machines; a sun-dial on the house, kites for the other boys, and at the same time developed an expertness with both pen and pencil; and it is even hinted that he wrote poetry; if so, none of it has ever come down to us. On leaving the school at about the age of sixteen years, for a time he was engaged in assisting his mother in farming and grazing. It is related that when he went to market with any of the produce of the farm, he would leave all the business of disposing of the produce to a servant who accompanied him; and that, in time, he would stop when half-way to the market and pore over books while waiting the return of his companion. He neglected his duties on the farm to devour some book, or to whittle out some new machine, or to watch the operations of some one that he had finished. His mother finally became convinced that

SIR ISAAC NEWTON.

(*From the original by Vanderbank.*)

he would never make a farmer, and thereupon determined to give him an education. He entered Cambridge University in 1661, and while there displayed a most surprising aptitude for mathematics; and it was while here that is said to have occurred the incident of the falling apple, although at the time he was temporarily at his homestead. Seeing the apple fall, it occurred to him that as the same power which drew the apple to the ground, operated from greater heights, its extension might be indefinite as to distance, and, hence, it might be the power which held the moon in her place. He reasoned that, as a ball fired from a cannon, describes a curve towards the earth in its flight, the same force which draws it to the ground might be the one which holds the moon in the curve which she describes in her motion about the earth. This was in 1665; but meeting some difficulty in adapting the theory to the facts, he abandoned the pursuit of the problem, and returned to some other occupation. He devoted some considerable time to experiments on refracting telescopes, and finally gave them up, and turned his attention to reflecting telescopes. He constructed one "with a concave metallic speculum, the radius of curvature of which was twelve and two-thirds, or thirteen inches, so that it collected the sun's rays at a distance of six and one-third inches. The rays reflected by the speculum were received upon a plane metallic speculum inclined forty-five degrees to the axis of the tube, so as to reflect them to the side of the tube in which there was an aperture to receive a small tube with a plano-convex eye-glass, whose radius was one-twelfth of an inch, by means of which the image formed by the speculum was magnified thirty-eight times."* This instrument was sent by

* *Life of Sir Isaac Newton.* Brewster.

request to the Royal Society, where it was still carefully preserved, in 1855, with this inscription: "The first reflecting telescope invented by Sir Isaac Newton, and made with his own hands."

This was in 1671; the next year he gave to the public his new theory of the doctrine of colors (the compound nature of light) and this involved him in a controversy, which took up most of his time for the next four years.

It will present a fair idea of some of the absurd speculations which were prevalent in those days to cite here one of Newton's conjectures as to the *cause* of gravity. "I shall set down one conjecture more which came into my mind, even as I was writing this letter; it is about the cause of gravity. For this end I will suppose ether to consist of parts differing from one another in *subtlety* by indefinite degrees; that in the pores of bodies there is less of the grosser ether in proportion to the finer, than in open spaces; and consequently, that in the great body of the earth there is much less of the grosser ether in proportion to the purer, than in the regions of the air; and that yet the grosser ether in the air affects the upper region of the earth, and the finer ether in the earth, the lower regions of the air; in such a manner, that from the top of the air to the surface of the earth, and again from the surface of the earth to the centre thereof, the ether is insensibly finer and finer. Imagine now any body suspended in the air or lying on the earth, and the ether being by the hypothesis grosser in the pores which are in the upper parts of the body, than in those which are in its lowest parts, and that grosser ether being less apt to be lodged in the pores than the finer ether below, it will endeavor to get out and give way to the purer ether below, which cannot be

without the bodies descending to make room above for it to go out into." *

Apart from this, it does not seem that Newton gave very much attention to gravitation, except as he says in his *Principia* as a purely mathematical concept, involving no consideration of real and primary physical causes. In the same work, he also says, the "reason of this property of matter, I have not as yet been able to deduce; and I frame no hypothesis." But, however careful Newton was not to definitely commit himself to an explanation of the cause of gravity, there were innumerable theories afloat during his time, among the most curious of which was that of Le Sage, and which is substantially as follows: "Space is constantly traversed in all directions by streams of infinitely small bodies moving with an almost infinite velocity, and coming from unknown regions of the universe. These bodies are termed 'ultra-mundane corpuscles.' By reason of their minuteness they rarely, if ever, collide, and the greater part of them find ready passage through ordinary sensible bodies, so that all parts of these bodies—those in the interior as well as those on the surface—are equally liable to be struck by the corpuscles, the force of the impact being thus proportional, not to the surfaces, but to the masses of the body. A single body or particle would be equally battered by these corpuscles on all sides; but any two bodies act as mutual screens, so that each receives a less number of impacts on the side facing the other. They are consequently driven toward each other. The motion of the corpuscles being rectilinear in all directions, the diminution of pressure thus resulting is inversely

* Letter to Boyle.

as the squares of the distances between the bodies affected." *

There are many discoveries to the credit of Newton, but there are three among them which are recognized as preëminent; they are fluxions, the theory of gravitation, and the compound character of light. It is perhaps worthy of note that all of these were discovered before he had reached twenty-five years of his life. His most celebrated work is his *Principia*, which consists of three parts, in the first of which he treats of motion in free space; in the second he speaks mainly of resisted motion; and from these two he deduces the system of the world. Something as to the profundity of the contents of this work may be inferred from the fact that not a half a dozen of the men of his times were able to comprehend them, and that even at the present day, the number who can follow their mathematical reasoning, and comprehend the elaborate conclusions is very limited; there are certainly none at all outside of mathematicians of the very highest proficiency. From the discovery of gravitation, he was able to explain nearly all the phenomena of the solar system. He found that the motion of the earth must have flattened it at the poles; that the influence of the sun and moon produced those oscillations of the ocean known as tides; and by a series of elaborate observations and calculations he was able to explain the precession of the equinoxes; although in the latter, he left much to explain by later astronomers. He gave much attention to the perturbations of the moon, but omitted all those in other heavenly bodies, while the most marked of those in the moon, known as evection, and relating to inequalities in the motion of the moon in its orbit, he failed to notice at all. Despite these and

* *Concepts and Theories of Modern Physics.* Stallo.

other defects, the importance and the generality of his discoveries respecting the system of the universe, and the most interesting points of natural philosophy, the great number of profound and original views which have been the origin of the most brilliant discoveries of the mathematicians of the last century, which were all presented with much elegance, will insure to the *Principia* a lasting preëminence over all other productions of the human mind.*

Newton not only gave a vast amount of study to the mathematics of astronomy, but he wrote and thought in other directions. He was one of the delegates to the noted high commission which was appointed to pass on the question as to whether or not James II., in his endeavor to establish Catholicism in England, could oblige one of the universities to confer a degree on a Benedictine monk without requiring of him that he should take the oath required by the laws against the Catholic religion. The opposition to the command of the king was so spirited that he withdrew the demand. Newton was appointed, and acted as warden of the mint; and wrote two works quite outside of his mathematical course of study and invention, one of which was, *Observations on the Prophecies of Holy Writ, particularly the Prophecies of Daniel and the Apocalypse of St. John*, and the other, *An Account of Two Notable Corruptions of the Scriptures.*

The first-named of these works contains a vast amount of research, covers an enormous field, and is a very curious production. He says of the scope of the work that the value and intent of prophecy are not that men may know what is to come, but that after events had occurred the prophecies might be verified. "The

* *Exposition du Systeme du Monde.* Par Compte Laplace. 1813.

folly of interpreters hath been to foretell things and times by this prophecy, as if God designed to make them prophets. By this rashness, they have not only exposed themselves, but brought the prophecy also into contempt. The design of God was much otherwise. He gave this and the prophecies of the Old Testament, not to gratify men's curiosity, by enabling them to foreknow things; but that after they were fulfilled, they might be interpreted by the event; and His own Providence, and not the interpreter's, be then manifested to the world.*

Newton was never married, and being frugal in his habits, he acquired a large fortune. He died at the age of eighty-five, and was buried in Westminster Abbey. The world's estimate of his character is summed up in the inscription on his monument: "*Sibi gratulentur mortales tale tantumque exstitisse humani generis decus.*"† His life was a rather uneventful one, its only disturbances being some controversies with some cotemporaries in regard to the priority and value of some of his discoveries. As a mathematician, the world has presented few, if any, who are his superiors; and yet with all his learning, he comprehended how very broad is the expanse of the unknown compared to that which he had investigated. It is of this phase of his nature, his humbleness, and his appreciation of how little he knew in comparison to what was yet to be learned, that is related the anecdote of the congratulations of his admiring friends, and the reply: "I know not what the world will think of my labors, but, to myself, it seems that I have been but a child playing on the sea-shore; now finding some pebble rather more polished, and now some other shell rather more agreeably variegated than

* *Age of Apocalypse.* Newton.

† Let mortals congratulate themselves that so great an ornament of the human race has existed.

another, while the immense ocean of truth extended itself unexplored before me."

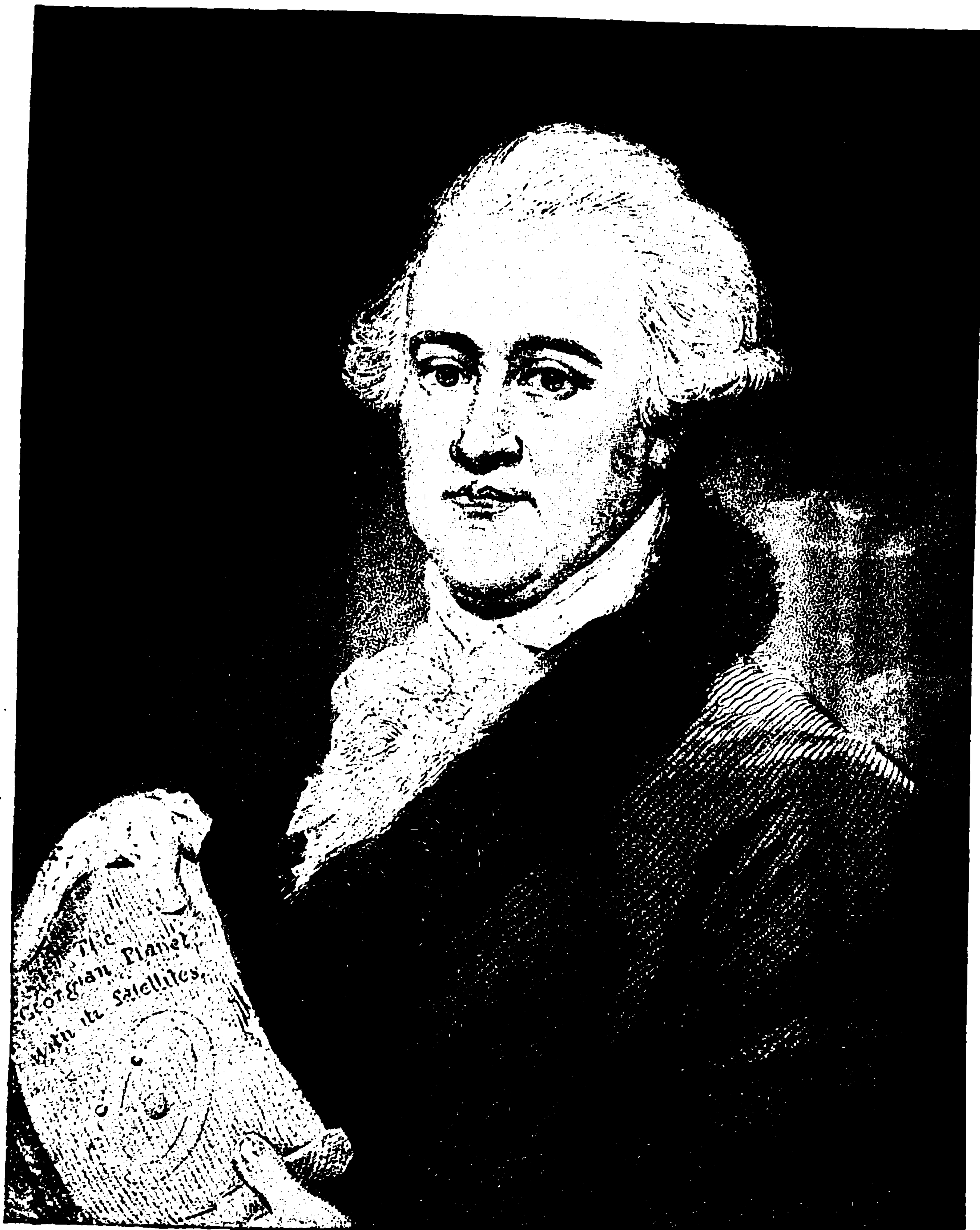
His gentleness is also exhibited in another well-known occurrence in which a favorite dog named "Diamond," played the leading part. The dog was left in his study while he went to church, and during his absence, upset a taper on some papers on the table, which were consumed, and which contained notes of experiments carried on through many years. He simply said, upon viewing the hard labor of years thus obliterated: "Oh Diamond! Diamond! thou little knowest the mischief thou hast done!"

It is useless to give any time to an effort proving the enormous value of Newton's life and discoveries to the world. No panegyric can over-estimate, no praise can rise to exaggeration. He discovered the key which unlocked the mysteries of the movements of the universe. He broadened immeasurably the area of human knowledge, and left it possible to extend, almost limitlessly, the field which he had so much enlarged. Before Newton, the world saw the planets moving about the sun, but they understood it as little as the savage understands the cause of the motion of the ocean steamer, or the railway train which speeds across the western plains. What was an enigma, and whose solution had wandered into the domain of the absurd, he made clear, rational, so that thenceforth men saw that behind every movement there is to be discovered an adequate cause.

While thus referring to astronomers, it may be well to give a little attention to some of those who succeeded Newton, and carried forward the work where he left it. Sir William Herschel is a name which is most familiar to the intelligent, and belongs to one who has played a very important part in modern science. He was the son of a musician, born in Hanover, November

15, 1733, and died near Windsor, England, August 23, 1822. He became a musician at the outset of his life, and remained thus till he was twenty-eight years of age, when he turned his attention to astronomy, in connection with the mannfacture of optical instruments. He made some telescopes of very excellent qualities, with one of which, in March, 1781, he discovered what at first was supposed to be a comet, but soon after was pronounced a planet, which was known by the name of its discoverer, but which is now known as Uranus. A little later, he discovered two of the satellites of the new planet. For these discoveries he was rewarded by a royal appointment, and a substantial salary. He now began his wonderful telescope, with which he estimated that not less than nearly twenty millions of the stars in the milky way could be seen. He made an important discovery in the character of twin, or binary stars, to the effect that both of the stars revolve around their common centre of gravity. His other discoveries are the resolving of the nebulous patches into clusters of stars, nebulæ, and nebulous stars; the fact that the stars decrease in number in both directions from the milky way in directions opposite to the northern and southern poles; and the further fact that our system is moving in a direct line towards another part of the sidereal system. He discovered two of the satellites of Saturn, and also made some additions to the knowledge of the properties of light and heat.

Pierre Simon Laplace was a cotemporary of Herschel, having been born in France, March 23, 1749, dying in Paris, March 5, 1827. Like Herschel, he was of humble origin. Like Newton, he did some remarkably good work before he was twenty-four years of age; and perhaps, it is but fair to regard him as second only to Newton in his knowledge of mathematics. He invented the



SIR W. HERSCHEL.

calorimeter for measuring the capacity of bodies of heat; "his discoveries of the cause of the discrepancy between the theoretical and observed velocity of sound, his rules for barometrical measurement, and his theories regarding capillary attraction, titles, and atmospheric refraction, show that in some of the most important branches of general physics, his mind was not less actively and profitably employed than in mathematical analysis. The crowning glory of his scientific career was his *Mecanique Celeste*, a book which has been truly said to have no predecessor, and which must wait for a second Laplace to arise ere it shall find a rival. In it he sought to digest on a uniform scientific basis the abundant materials relating to the application of analysis to physical astronomy, which had been so accumulating during nearly a century, and which, written in various languages, with differing notations and in various stages of scientific progress, presented a mass of matter not only difficult of access, but almost incomprehensible to any but the most recondite student." *

Urbain Jean Joseph Leverrier is of the present century, having been born in France in 1811, and died 1877. He made several corrections of theories in existence relative to astronomical matters, but the first event that gained him notoriety was his announcement that certain movements in the perihelion of Mercury could only be accounted for by the existence of another planet which was soon after discovered within two degrees of the point which he had indicated. At first, as in the case of the discovery by Herschel of a planet, it was named from the discoverer; but, in time, the new planet, Leverrier, became changed to Neptune. His subsequent discoveries have reference mainly to the existence of

* *Am. Cyclopædia.*

asteroids, and investigations into the theories of the four large planets.

General Mitchel, who died during the late civil war, obtained some considerable repute as an astronomer, for some discoveries which he made in the heavens, and for the construction of some ingenious instrument for observation of the heavenly bodies. Mr. Proctor, of England, has a world-wide reputation. He has been a most diligent student and worker, having published a large number of different volumes on astronomical subjects, all of which have been well received, and some of which have attained a fabulous circulation.

CHAPTER XIII.

ALCHEMY AND CHEMISTRY.

CHEMISTRY is variously defined; it has been regarded as the making of gold and silver; as the art of making chemical preparations and the extracting of pure essences in a separate form from mixtures; as the science which makes known to us the nature and property of all bodies by composing and decomposing them; as the art of separating the different substances which occur in mixtures; as the science which investigates the components of bodies in regard to their nature, their properties, and the manner in which they are combined; and finally that in which it stated that "Nature is composed of certain elementary bodies or elements. The knowledge of these bodies, of their mutual combinations, of the forces by which these combinations are brought about, and of the laws in accordance with which these forces act, constitute chemistry." *

In its present character, chemistry is of recent origin. That it was known, in some of its present forms, to the ancients, cannot very well be disputed. There is everywhere to be found evidence in the architectural remains, and the writings of the Egyptians, the Hebrews, the Phœnicians and the Greeks, that they possessed a certain amount of chemical knowledge. The smelting of

* Berzelius.

ores is a chemical act; so is dyeing; the making of glass, and its coloring are chemical operations; and all these were known to, and practiced by, the ancients long anterior to the Christian era.

The first that is definitely known to us of chemistry since the time of Christ, is in the form of alchemy, or the effort to make the precious metals by artificial means. For nearly or quite fifteen hundred years chemistry was devoted to this single end, and such discoveries as there were in chemical science during this long period were accidental, or incidental to the main effort. It is supposed by some writers that the attempt to transmute the baser metals into gold—or what was the same thing, to find the philosopher's stone whose simple touch would produce the desired result—came from the Egyptians to the Arabs, and thence through Spain to the nations of northern Europe.

The alchemists always attempted to throw an air of mystery around their art, and hence, the majority of them have carried its origin back to the mythical Egyptian, Hermes Trismegistus, of whom the world has heard so much, and knows so little. He was a species of embodiment of the highest attainments of the human mind; the name being derived from Hermes meaning the intellect, and the Greek words, *tris megistos* (thrice greatest). His works are claimed to "contain the sum total of human and divine wisdom." The works which were attributed to his authorship were probably written by others; in any case there is not the slightest reason for concluding that any such person ever had an existence. There are evidences of the presence of alchemy through the earlier centuries; but its greatest triumph was during the fifteenth, sixteenth, and seventeenth. During the last-named, it rose to its highest point, and then disappeared as suddenly as a morning mist at sunrise.

According to the majority of the alchemists, all metals are composed of sulphur and mercury—the latter not being the substance now known under that name—but a something which represents the element proper of metals, the cause of their brightness, their ductility, in brief, the *metality* of metals; while what was called sulphur indicated the element of combustibility. The theory of the generation of metals was clearly taught by the alchemists. They compared the birth or formation of metals to that of the birth and growth of animal life; they saw no difference between the development of the fœtus in the matrix of the animal, and that of the metals in the bosom of the globe.* They were of the opinion that the metals were endowed with a species of life; and that if anything but gold had birth, it was of the same character as the monsters of abortion which occasionally occur in human experience. Salmon says that it must be admitted that the intention of nature is not to create lead, iron, copper, tin, nor even silver; but to create only gold. If some other metal than gold is produced, it is not the fault of nature, but of circumstances, of obstacles which are encountered. What was intended, and should be gold, owing to the impurity with which the mercury has become tinged by contact with the matrix, and by the alliance which it makes under unfavorable circumstances with bad and combustible sulphur, becomes some other metal.

Later, the alchemists gave more attention to the discovery of the philosopher's stone, which had three qualities; to change the baser metals into silver or gold, to cure all maladies, and to prolong human life far beyond its natural limits. The efforts to find this stone were made assiduously for hundreds of years, and included

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* *Doctrines et Travaux des Alchimistes.* Louis Figuier.

researches in directions the most *bizarre*, and the most unexpected. The recipes for constructing this wonderful stone are innumerable; sometimes given in comprehensible language, but oftener veiled in mysterious terms. One cannot but help thinking that all this mystery was employed as a veil of ignorance. One of these recipes commences with, "take of some unknown thing the quantity that you wish;" and another says: "take some mercury, and solidify it with magnesia, or with sulphur, or with silver foam, or with lime, or alum, or anything that you wish." The idea of sex was prominent; arsenic was regarded as one of the greatest value; salt stood in high favor; saltpetre had its day; the vegetable world was investigated to furnish the materials for the stone; and later, it was sought for in animal products. The human body was for many years believed to be a receptacle which contained the sought-for treasure. All forms of human excrementory matter was regarded as of value, and innumerable were the investigations made in this direction whose particulars would be too indecent, or too disgusting for publication.

During the sixteenth century, the alchemists occupied themselves in trying to obtain a universal solvent, or menstruum, which they termed *alkahest*. The search for this universal dissolvent was continued till the eighteenth century, when it was succeeded by a demand for palingenesis, or the power to secure the re-birth of plants and animals from their ashes. Perhaps it is better to say the resurrection of something which resembles the plant and the animal, which can be recognized, but which is not the original in all its qualities. The palingenesis epidemic was followed by one having reference to the homunculus; that is, the creation by chemical processes of a miniature man not more than an inch in length, and which possessed all the qualities of a

human being. It is needless to say that although there are many reports of success in this effort, there is nothing on record which permits the conclusion that any homunculi were created by chemical processes.

If the reader have any curiosity in regard to the creation of the homunculi, he may have it gratified in the following from the noted Paracelsus:

"As for me, I affirm that the creation or producing man outside of the natural processes is not above the art of the chemist; that it is not at all repugnant to nature, and that it is perfectly possible. This is the manner of proceeding in order to attain this result: Enclose during a space of forty days some *sperma viri* in an alembic till it putrefies, and to the point where it commences to live and to move, which is easy to be recognized. After this it will begin to appear in a form like that of a man, but transparent, and nearly without substance. If, after this, this young product is nourished every day carefully and prudently with human blood, and kept, during a space of four weeks, in a temperature unchangeably equal to that of the belly of a horse, the existence will become that of a true and living infant, with all its members, just like that born of woman, only smaller. This is what we call the homunculus. It is necessary to rear it with much intelligence and care while it is growing, and up to the time that it begins to be possessed of intelligence. This is one of the grandest secrets which God has revealed to sinful man. It is a miracle, one of the grandest results of the power of God, a secret above all secrets, which deserves to be concealed until that time when there shall no longer be anything concealed from all." *

Despite all the folly, and the absurdities involved in

* *De Natura Rerum.* Paracelsus.

these pursuits, they have not been without benefit to science, although rarely, if ever, in any intended direction. They spent their lives and the centuries, did these alchemists, in the search for the philosopher's stone, the elixir of life and health, and various other potent agencies. Modern chemistry owes much to these hermetic explorers. Geber, an Arab, and a writer, describes mercury, silver, lead, copper and iron, and he also gives the first description to be found of many substances in use in modern laboratories. The Arabs knew of and described alum, saltpetre, sal ammoniac, and green vitriol; and the preparation of sulphuric acid by the distillation of alum; the carbonates of the fixed alkalies, and the use of lime to render them caustic; the making of nitric acid, by the distillation of saltpetre and green vitriol; the preparation of strong acetic acid from vinegar, and of *aqua regia* from nitric acid and sal ammoniac. In the thirteenth century lived Albertus and Roger Bacon, both of whom in their search for the philosopher's stone made many discoveries of value. In the fifteenth century, Basil Valentine describes bismuth and zinc; he prepared antimony and several new salts, also muriatic acid by distilling common salt with green vitriol. He had a very fair knowledge of what is known as precipitation. Paracelsus in the first part of the sixteenth century, an explorer for gold, was yet the means of inaugurating a reform, during the existence of which chemistry and alchemy began to break their long and intimate connection. He held to the belief that there are but three elements in all things, organic and inorganic—mercury, sulphur, and salt; a number which has vastly increased within the period since his day to the present, there being at the present not less than sixty-three elements recognized, while at least two others are held in doubt. When the separation between alchemy

and chemistry had been continued a short time, a new alliance was formed between chemistry and medicine.*

There is something most remarkable in the length of the existence of this search for the philosopher's stone; in the extent to which it spread, and the number of people who were deluded into believing its verity. One pope launched a bull against the search, and Henry IV. of England tried his hand at putting it down by a law making it a penal offence; but all to no end. There were mighty people who patronized it despite the action of Henry and Pope John. Rudolph II., emperor of Germany, in 1576; the elector of Saxony, Augustus, his wife, Anne of Denmark, and his successor, Christian; Ferdinand III., emperor of Germany; Leopold I., also emperor of Germany; Frederic I. and Frederic II., kings of Prussia; Queen Elizabeth; Alphonse X., king of Castile; Charles IX., of France; Christian IV., king of Denmark; and many another of high degree, put their trust in alchemy, and patronized and pensioned liberally the impostors who prevailed on them to believe that they had the power to transmute the base metals. The strength of this delusion may be inferred also from the fact that despite the fact that there is not a single perfectly-authenticated case in which the base metals have been transmuted, the search for the grand secret continued even into the present century. As late as 1854, a French chemist presented to the French Academy of Sciences some minutes, in which he undertook to prove that by the use of an acid on silver, he had produced gold artificially; although, in an attempt to produce the same result in Paris—the other experiments having occurred in America—he failed disastrously. Even at the present time there are to be found alchemists in

* *Am. Cyclopædia.*

many of the cities of Europe, and more especially in Germany. They are of the belief that the secret has been known, and they are ready to cite innumerable instances in which gold in unlimited quantities has been produced by this or that professor of the hermetic art. Legends of this nature circulate among them as facts, are believed, and stimulate their endeavor to recover the precious secret.

There have been some noted men brought to the notice of the world in connection with the study of chemistry, ancient as well as modern. One of those, whose name is often quoted, is Paracelsus, who was born in Switzerland in 1493, and died in Saltzburg in 1541. He had another name, which may be worth mentioning as a curiosity, viz: Philippus Aureolus Theophrastus Bombastus von Hohenheim, which, being of inconvenient length for family use, was probably contracted into the name by which he was best known to the cotemporary world. He picked up some medicine, some chemistry; some thaumaturgics, a little astrology, and a few other accomplishments, and then started for the grand tour of Europe. He secured some remedies for the cure of human ailments, during his travels, and then set up business as the only great healer of the age. He did perform some cures, for which he received the appointment of professor of physic and surgery in the University of Basle. He then took the position that he was the only true exponent of physic; he publicly burned all the books of the accepted authorities on medicine, and declared that he was able to prolong life and cure all human maladies. In these assumptions he was the ancestor of the modern quack, who professes with his single remedy to cure all diseases. In his chemical character, he was of the opinion that there are three elements, or three compound principles—salt, sulphur

and mercury. The soul, he taught, was united to the body by an animal fluid; that man is an image of the Trinity, his intellect being God, his body the world, and the fluid the stars. He recognized a mysterious harmony between the body and the earth and salt; between the soul and water and mercury; and between the intellect and the air and sulphur.* Despite the renown which he obtained, he became an inebriate, lost his position, became a vagabond, and died among strangers. Despite the character thus obtained by him, there are authorities which look on him as the one to whom is due the credit of having inaugurated the reform which chemistry experienced at this period. He made some discoveries, it is true; but it is nevertheless true that if he was of value in chemistry, he was a quack who has been without a rival unless it be in the person of the famous Cagliostro, of a later period.

Another man who did much to raise chemistry from the vulgar and useless domain of transmutation, was Georg Ernst Stahl, who was born in Germany in 1660, and died in Berlin in 1734. He was highly educated, a physician, and a chemist. He was a strong believer of the phlogiston theory, to the effect that all combustible things owe their character to the possession of a certain ingredient, which is termed phlogiston. A body was combustible in proportion to the amount of phlogiston which it contained. But he did not confine himself to this single idea; he still gave a little attention to alchemy, and his contributions to the science of chemistry have been neither limited nor valueless. Another theory which he evolved was the "existence of an *anima*, or immaterial principle resident in the body, creating its organization, and governing all its

* *Am. Cyclopædia.*

processes with reference to the final purpose of preserving life."

Joseph Black, son of Scotch parents, was born in Bordeaux in 1721, and died in 1799, at Edinburgh. He held the chemistry professorship for many years in the city where he died. He was a delicate man, with some hereditary weaknesses, but managed to prolong his life by rigorous care of himself and by an abstinence that was almost miraculous. His first discovery of note was of carbonic acid gas, and his next of what is termed latent heat, which was followed by his announcement of specific heat, or the capacity of different bodies for heat. The discovery thus made was regarded as of great importance. "The universal operation of heat, and the agency which, by its absorption and its evolution, it exerts on the structure of all bodies, renders the discovery of its nature and action in these respects, next to that of gravitation, the most important step which has been made in the progress of physical science. The new field opened to philosophical inquiry by the discovery of the gaseous bodies is only second to the former in the importance of its consequences." *

As in the case of Newton, Black developed early. His first discovery was made when he was but twenty-four years of age; and his second, when he was thirty-four.

Another well-known name in connection with chemical progress is that of Dr. Joseph Priestly, who was born at Leeds, England, in 1733, and died in 1804. He was of humble birth, his father being a cloth-dresser, but he was cared for by his aunt, who gave him some schooling. When he was twenty-two, he took orders, but did not prove acceptable as a clergyman, and thereupon he left

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* *Philosophers.* Lord Brougham.

the pulpit and became a teacher. He then began a series of works on natural and revealed religion, the claims of the Roman Catholics, the French revolution, the American war, and in brief, on all possible topics save those upon which his reputation rests. His first chemical studies were directed to an examination of "fixed airs," and he soon made the very important discovery that atmospheric air which has been vitiated by the respiration of animals is purified by the action of plants; and a year later, in 1774, in making some experiments, he discovered an æriform body which had the effect to increase the intensity of flame, and which was at first called "dephlogisticated air," but which soon came to be known as oxygen. It is asserted by Lavoisier that he, Priestly, and another chemist named Scheele, all discovered this gas at the same time; but this is vehemently denied by English authorities, who affirm that the knowledge of it was communicated by Priestly to Lavoisier, and that he took advantage of this fact to claim that he was one of the discoverers. He was an intolerant polemic in regard to religious doctrines, for which he was so persecuted—his house and chapel, and all their contents being burned by an excited mob—that he came to America, in 1794, where he remained for some ten years. He soon created many enemies on account of his political and religious doctrines; and concerning this, there is a curious anecdote related by Lord Brougham:

"In America, we find all his leanings against the federal party, and his censures of the great chief of the union little concealed. He felt for the democratic party, the French alliance, the enemies of English partialities, and he regarded Washington as ungrateful because he would not, from a recollection of the services of France twenty years before to American independence, consent

to make America dependent upon France. The indifferent reception which he met with in society was probably owing to this party violence full as much as to dislike of his Unitarian opinions. But it must be added that his temper was so mild, and his manners so gentle, as to disarm his most prejudiced adversaries whenever they came into his society. Many instances of this are given in his correspondence, of which one may be cited. He happened to visit a friend whose wife received him in the absence of her husband, but feared to name him before a Calvinistic divine who was present. By accident his name was mentioned, and then the lady introduced him. But he of the Genevan school drew back, saying, 'Dr. Joseph Priestly!' and then *added in the American tongue*, 'I cannot be cordial!' Whereupon the doctor said that he and the lady might be permitted to converse until the return of the host, saying this with his usual placid demeanor. By degrees the conversation became general; the *repudiator* was won over by curiosity at first, then by gratification; he remained till a late hour hanging on Priestly's lips; he took his departure at length, and told his host as he left the house, that never had he passed so delightful an evening, though he admitted that he had begun it by 'behaving like a fool and a brute!'* He endeavored to establish a congregation of Unitarians at Philadelphia, and to extend his Unitarian belief as widely as possible. He was an invalid two years before his death, but bore all his sufferings, and faced death at last without flinching."

Antoine Laurent Lavoisier, whose period extended from 1743 to 1794, played no inconsiderable part in bringing chemistry forward. He was the first to dispose

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* *Lives of Philosophers.*

oi the phlogiston theory, by showing that the reason why metals undergoing combustion become heavier is, that they take something from the atmosphere. Says a well-known writer: "As an investigator, Lavoisier stands preëminent. His precision of observation, ingenuity in devising apparatus, and his patience, are only equalled by the clearness of his conclusions and his masterly description of facts." He made many discoveries of the most important character, more especially in regard to the gases, the composition of sulphuric and other acids, etc., etc.

Another chemist who came forward at this period, and assisted in elevating his chosen science by expanding its area, and increasing its practical value, was Henry Cavendish, who was born in Nice, where his mother had gone from England for her health, in 1731, and who died in March, 1810. He was of noble parentage, and of colossal wealth; but he gave his entire life to science. He is noted for two great discoveries, the composition of water, which although before suggested, was by him demonstrated by synthetic experiments. He filled a glass globe with a portion of hydrogen gas, and then sent through the mass an electric spark. There remained no hydrogen, and a considerable portion of the common air had disappeared, and there was some water, and with it an acid. By another experiment, he burned a mixture of oxygen and hydrogen in the glass globe, when both of them disappeared, and there remained water, equal in weight to the two gases before their combustion. The other discovery was that nitrous acid is composed of nitrogen and oxygen, with the latter in a lower proportion than in the composition of nitric acid; or, as Cavendish's biographer expresses it, "that nitrous acid is composed of the two airs which form our atmosphere, deprived of latent heat." He made some

important investigations upon the force of gravity; and wrote some papers on electricity.

Sir Humphry Davy is a scientist who has earned and occupied a large share of the world's attention, owing to his invention of the safety-lamp, and which has been the means of preventing the loss of thousands of lives from explosions in mines from "fire-damp." He was born near Penzance, in England, 1778, and died in Geneva from an apoplectic stroke, in May, 1829. He made many chemical investigations with electricity, and is claimed by English writers to have discovered the metals known as potassium and sodium. However great these may have been as discoveries, they fall far short of the safety-lamp. In making some experiments as to how the flames are communicated to the fire-damp, he found that the flames would not pass through certain tubes having a small bore. He also found that the shortness of the tubes made no difference provided the size of the opening was proportionally reduced. Thus shortening the length of the tube, and the diameter of the opening, he finally reached the conclusion that the flames would not communicate through the fine meshes of woven wire. Thereupon he surrounded the flame of the lamp, or candle, with a fine wire gauze; and from that time, there have been no accidents from explosions not produced by the carelessness, or recklessness of the working men.

It would require a volume to give the names of all those who have been conspicuous for their discoveries in chemistry, and to give even the briefest outlines of their lives. There are Liebig, Dalton, Gay-Lussac, Thenard, Berzelius, the noted Faraday, Mitscherlich of Berlin, Woenler, Kopp, Gibbs of New York, Genth of Philadelphia, Bunsen of Heidelberg, Prof. Cooke of Cambridge, Mass., Schoenbein, Schroetter, Draper,

Gerhardt, all of whom have done much to assist in the development of chemistry, and to bring it to its present lofty position.

As to the value of chemistry in practical life, or as to its value in the development of civilization, there is no necessity of saying a word. It is to-day an element in human development, whose absence would be almost fatal. In the detection of cases of poisoning its assistance is invaluable. By its aid, the pharmacopœia has been enriched beyond estimate. In commerce, manufactures and the trades, it is of incalculable value. It discovered malt, glucose, glycerine, uses for petroleum, anæsthetics, and artificial ice. It analyzes ores, and pronounces on their value, and directs their smelting; from the refuse of the gas manufactories it has obtained materials so valuable that the making of gas for the sake of the residuum would be valuable, were the illuminating product given away. It discovers adulterations in food and in liquids; it gives the formula for the "baking-powder;" it has discovered all the thousand dyes in use in stuffs for wear; it bleaches cloths, it washes them; it disinfects the nests of epidemics, prevents the spread of disease, is the principal assistant of the sanitarian; it purifies the food we eat, and the air we breathe; furnishes the soap with which we wash, and in ten thousand other ways, and methods, is an ingredient in the ornamentation, the utilities, the comforts, and luxuries of life.

CHAPTER XIV.

PERPETUAL MOTION.

SOME details connected with the search for perpetual motion will be of value, if simply to demonstrate its impossibility. It may be supposed that the search for this kind of a movement died out when alchemy had run its course, some one or two hundred years ago. That there is less now of this pursuit than there was then needs not be doubted; but that it has lost its hold upon the fancy and effort of men is a mistake. Twenty years ago there were to be found so-called inventors who sought for a machine which would move itself, and continue in motion so long as its materials lasted; and there are many even to-day; but as a rule, they have so much to encounter in public opinion, that they carry on their experiments in private.

The fact that there are men who still devote themselves to this search can be explained on the ground that there is a belief, not narrow in its extent, to the effect that perpetual motion machines have been constructed. They who attempt to construct one of this class, do not labor to invent one, but to reconstruct, or reproduce one. They are firm in the belief that such machines have been made; there are those who claim to have seen them; the thing can be done, they assert; but they do not know the secret of the construction, and this is what they are engaged in solving. Could

such men be convinced that no such machine has ever been made, it would materially alter their plans. The mischief in their case is that they insist that the secret has been discovered, and that what has been done can be done again.

There was a time when the search for perpetual motion engaged the attention of the very best talent of the age; of late years, the men who have wasted their lives in a futile effort to discover the undiscoverable are often men without education, and without mechanical ability.

It may be remarked that the modern condemnation of perpetual motion as being both an absurdity and an impossibility is not in accord with the writers of a half a century, or a century ago. In fact, there have been many eminent authorities who claim that it is possible, among whom are Bishop Wilkins, Leopold, Nicholson, and others who occupied high positions in the world of science and mathematics. The answer to them is that, although an infinite number of attempts have been made in this direction, and an almost equal number of claims have been made of success attained, there is not in history a single reliable instance of any such machine being constructed.

What is perpetual motion? In briefest terms, it is a machine which will move itself, and will continue moving so long as is not interfered with, till the materials of which it is composed wear out. A machine that will continue in motion till it is worn out is not necessarily a perpetual motion machine, for such a one might be put in motion by a stream of water, by the tides, or the wind. Nor would a machine in which the motor is electricity belong to this class; it must be one in which the motor is a part of itself, which is not renewable from external sources. A water-wheel turned by water from

a reservoir, which should put in motion a pump which would elevate the water used to turn the wheel back to the reservoir, would be perpetual motion. Ogilvie defines it thus: "That which generates a power of continuing itself forever, or indefinitely, by means of mechanism or some application of the force of gravity not yet discovered. The celebrated problem of a perpetual motion consists in the inventing of a machine which shall have the principle of its motion within itself, and numberless schemes have been proposed for its solution; but unless friction and the resistance of the air—which necessarily retard, and finally stop, the motion of machines—could be removed, a perpetual motion must be impossible from any pure mechanical combination. The problem, when strictly investigated, amounts to this: namely, to find a body which is both heavier and lighter at the same time, or to find a body which is heavier than itself. In speaking of perpetual motion, it is to be understood that from among the forces by which motion may be produced we are to exclude not only air and water, but other agents such as heat, atmospheric changes, etc. The only admissible agents are the inertia of matter and its attractive forces, which may all be considered of the same kind as gravitation."*

According to Dircks, the first recorded attempt to secure perpetual motion was made in the thirteenth century; and what seems strange is that the original attempt (and failure) is substantially the same as has been tried a thousand times since. The inventor was a French engineer, named Wilars de Honecort, and there yet remains in Paris his own drawing of the machine. The machine consisted of a wheel, to whose periphery were

* *The Imperial Dictionary, English, Technologic, and Scientific.* John Ogilvie, LL. D. Glasgow, 1854.

attached seven mallets with long arms, so jointed to the wheel that they would either extend out from the wheel or lie close to it, according to the position in which they were placed. The theory of the inventor was that as one side of the wheel descended, the arms of the mallet would be extended, while on the ascending side they would lie close to the wheel, falling there by their own weight. At first sight it would seem as if the side with the extended mallets would be carried on down by the extended weights, and carry up the other side, whose weights lie close to the surface; but in practice, it is found that no matter how many weights there are used, there would be more on the ascending, than the descending sides.

In the fifteenth century, Leonardo da Vinci, the celebrated artist and mathematician, designed six forms of machines embodying the principle of perpetual motion. In each of them, as in the case of the machine of Honecort, the device for securing the motion is one which it is sought to over-weight a wheel on the descending side.

In 1610, Cornelius Drebble constructed a machine which was believed to be self-operative, and which was designed to prove that the heavens move about the earth. The inventor was a German, but was acting as engineer for King James of England, to whom he presented the machine. A cotemporary writer describes the principle of the machine in a manner which is at least curious, if it does fail to be comprehensible. He says that "fire is the most active and powerfull element, and the cause of all motion in nature. This was well known to Cornelius, by his practice in the untwining of elements, and, therefore, to the effecting of this great worke, he extracted a fierie spirit out of the minerall matter, jointing the same with his proper aire, which encluded in the Axletree, being hollow, carrieth the

wheels, making a continuall rotation or revolution, except issue or vent be given to the axletree, whereby that imprisoned spirit may get forth. . . . To the end of time may not weare these wheels by their motion, you must knowe that they move in such slow measure, that they cannot weare, and the lesse, for that they are not forced by any poyse of weight." He then refers to an instrument of "perpetuall motion" which he afterwards presented to "Charles the fift Emperour, wherein was one wheele of such invisible motion, that in seventy yeares onely his owne period should be finished." *

This machine of Drebble is a famous one among those who believe that perpetual motion has been accomplished; but the reader will be able to draw his own conclusion from Tymme's explanation of the power by which this wonderful machine was driven.

The original of the hydraulico-perpetual motion machines was the invention of Valentine Stansel. In this, there are two cisterns, one above the other; from the upper one there flows a small stream which turns an overshot-wheel. This wheel, by means of a crank, works the piston of a force-pump which drives the water from the lower cistern up the upper one, where it supplies the waste employed in driving the wheel. During this period there were many attempts to produce perpetual motion, many of them being in the nature of demonstrations (so-called) on paper, no machine or model being constructed. There was a water-clock projected by Martin in 1640 which was expected to be self-acting; and in fact was so in theory, but was a failure in practice. A writer of a little later period describes a score or more of machines which were to be self-acting, and for the purpose of raising water. Then there were some attempts made to secure

* Thomas Tymme, Professour of Divinitie; 1612.

perpetual motion by the use of the load-stone acting on iron-balls, the most famous of which was by Dr. Jacobus.

During the seventeenth century, there was published a multiplicity of books by such men as Gaspar Schott, Bettinus, Borelli, Dr. Becher, De Stair, Bernoulli, Robert Stewart, Ernest Neumann, Ferguson the astronomer, and scores of other men, eminent many of them in learning, with a view of demonstrating the feasibility of constructing machines that would be perpetual and self-acting. The first machine which has come prominently before the world is the invention of the Marquis of Worcester, the inventor of the use of steam for the pumping of water. It was in about 1641 that he completed his machine; and it may be added that the fact—if it be a fact—that he created a machine possessed of perpetual motion, rests largely on some of his own utterances. It is described as consisting of a wheel some fourteen feet in diameter, and carrying forty weights of fifty pounds each; and it is supposed that it was of that kind of perpetual motion machines, in which an attempt is made to secure movement by pushing the weights out from the centre on the descending side of the wheel, and having them fall nearer the centre on the ascending side. If the marquis succeeded in making his machine work, he did what nobody else has been able to do with precisely the same class of machine.

The Marquis of Worcester was a man who cannot well be suspected of knowingly perverting the truth; there, then, only remains the conclusion that he has been misunderstood as to his statement that the motion he secured was perpetual in its character. As the inventor of the steam-pump, Worcester does not need the doubtful honor of an invention which the world believes to be impossible; his steam-pump remains as an evidence of his genius; of his perpetual motion machine there is

not a trace. Those who are familiar with the peculiar style and language in which he announced his discoveries are in a condition to very easily understand that nothing is easier than to misapprehend his meaning. This will be seen by the reader when the Marquis is handled more in detail in a later portion of this work.

Far in advance of the discussion over the alleged invention of perpetual motion by the Marquis of Worcester, is that which has taken place over the machine of Orffryreus. He was born in Saxony, and his machine attained its greatest celebrity in 1712. It is thus alluded to:

"We find in this case, that a wheel, freely suspended on one axis, and impelled by no perceivable external motive power, revolved swiftly, and continued to do so with an extremely equable motion. There were not wanting some among those who saw it, who endeavored to injure the ingenious inventor. A paper was distributed asserting that the wheel was set in motion by a concealed artifice, viz: by a man seated in an adjoining room, and the contrivance was hidden from the view of the spectators by an engraved brass plate. J. E. E. Orffryreus, in the meantime, went from the village of Draschwitz to the suburbs of Martinsbury, and there constructed a perpetual motion machine on a somewhat larger scale. The diameter was almost twelve feet, and the thickness one foot: the diameter of the axle-hole was six finger-breadths; but the thickness of the small iron axle was scarcely a fourth part of this, in order that the friction might be reduced as much as possible, and the motion not retarded by a weight of seven hundred pounds, which was raised by the machine. He thus silenced his detractors, not by words, but by deeds.

"On the 31st of October, in the presence of commissioners whom he had requested from the most serene

Duke of Saxony, Maurice William, to attend, viz: that truly high-minded man, celebrated in several writings, now published and received in these 'Transactions,' and skilled also in mathematics—Julius Bernhard of Rohr, assessor of the reigning duke—the ducal secretary, and other officials, eminent for birth, station, and gifts of dignity and erudition, of whom it may suffice to mention Wolff Dietrich, of Boshen, Frederick Hoffman, the celebrated physician, Christian Wolff, and Menckenius, he transported the wheel from its place to another situation, where there were no walls contiguous to it, and where one might go freely round it on every side. Orffyry did not attempt to conceal that his machine was set in motion by weights.

"He came again to see the machine, with some of his ministers on the 26th of November; and the chamber, having been unsealed and opened, the machine appeared in motion as before. He then ordered the windows and doors to be again closed and sealed up; and on the 4th of January of the present year, the seals having been removed, which were acknowledged to be untampered with, he ordered the chamber to be looked into, and saw Orffyry's wheel even then going round at its accustomed speed.

"The prince, inclined as he was to mathematical science, and especially to mechanics, did not hesitate to attest this under his name and seal, and at the same time to pledge himself that the construction of the machine was not such that it required winding up." *

In regard to the same machine, there is the testimony of Baron Fischer, the architect to the Emperor, who says of it that, "it is a wheel which is twelve inches in diameter, and covered with oil-cloth. At every turn

* *Learned Transactions.* Leipsic, 1777.

of the wheel can be heard about eight weights, which fall gently on the side on which the wheel turns. This wheel turns with astonishing rapidity, making twenty-six turns in a minute, when the axle works free. Having tied a cord to the axle, to turn an Archimedean screw to raise water, the wheel then made twenty turns a minute. I then stopped the wheel with much difficulty, holding on the circumference of the wheel with both hands. An attempt to stop it suddenly would raise a man from the ground. Having stopped it suddenly (and here is the greatest proof of perpetual motion) I commenced the movement very gently to see if it would of itself regain its former rapidity, which I doubted, believing as they said in London, that it only preserved for a long time the impetus of the impulse first communicated to it. But to my great astonishment I observed the rapidity of the wheel augmented little by little until it made two turns, and then it regained its former speed, until I observed by my watch that it made the same twenty-six turns in a minute as before, when acting freely; and twenty turns when it was attached to the screw for raising water. This experiment, showing the rapidity of the wheel augmented from the slow movement that I gave it, to an extraordinary rapid one, convinces me more than if I had seen the wheel moving a whole year, which would not have persuaded me that it was perpetual motion, because it might have diminished little by little until it ceased altogether; but to gain speed instead of losing it, and to increase that speed to a certain degree in spite of the resistance of the air and the friction of the axles, I do not see how any one can doubt the truth of this action. I also turned it in a contrary direction, when the wheel produced the same effect. I examined well the axles of this wheel to see if there was any hidden artifice, but I was unable to see

anything more than the two small axles on which the wheel was suspended by the centre." *

In truth, the machine of Orffryreus excited a vast amount of discussion, in which several men of eminence took part; the inventor broke it up in a rage one day, owing to some insinuations from an examiner to the effect he was an impostor, and its secret was never discovered. Volumes have been written concerning this wheel; and up to the close of the last century, it was the opinion of the majority of those who gave the matter attention, that it was a genuine case of perpetual motion; and it may be said of it that if it were an imposture (as it must have been) nobody has succeeded in demonstrating it.

During the seventeenth century, there were three patents taken out in England for machines self-acting and perpetual in their movement, and several times as many during the next century. One of the former was patented by David Ramsaye in 1630, as follows: "David Ramsaye esquire, and one of the groomes of the Privie Chamber." Among other claims to a patent for his "great paines, industrie, and charge" in finding out the same, he names, "to make any sort of mills to goe on standing waters by continuall mocion without the helpe of winde, water, or horse." No description is given, as none was required. Ralph Wayne, gentleman, in 1662, "hath through his great charge, labor and industry attained the knowledge of an engine which, with the perpetual motion of itselfe without the help or strength of any creature or person, will not only drain great levels of vast quantities of water, but also mines of fifty fathoms deep or more."

A curious machine is that of Hildebrand Morley, of

* Baron Fischer to Dr. Desaguliers.

Clement's Inn, Middlesex, gentleman, in 1782, and which is for the purpose of communicating motion to clocks, mills, time-pieces, or other "instruments or engines requiring the same properties, a constant and perpetual force and motion." Fortunately for posterity, the inventor gives some specifications which will enable us to comprehend somewhat the principles which were involved in the construction of his machine. He describes it as follows:

"My said invented wheel, engine, or machine, whereby to give or communicate to mills, clocks, time-pieces, or other instruments or engines requiring the same properties, a constant and perpetual motion, has a frame-work of wood, iron, or other metal to which the machinery is fixed and supported. It consists of a wheel, which is divided on the rim or outward edge into any number of divisions, in the manner of a water-wheel, so that each division be sufficient to contain a round ball, which balls are made of wood, or hollow balls made of tin, copper, iron, or other metal, or of glass. These balls, as the wheel moves round, fall off on an inclined plane or spout, from whence they acquire sufficient velocity or force to enter through a passage a tall, square tube filled either with quicksilver, water, or other fluids, which is there supported by the pressure of the outward air. As soon as the balls enter the aforesaid tube they will rise upwards therein, being lighter than the fluid, and through a certain number of newly contrived valves, which support the fluids alternately in the tube. When the balls are arrived at the top or broad head of the aforesaid tube, they are conducted to a wheel with a certain number of teeth, on which are place-lifters to lift the balls out of the said fluid. This said wheel is drove by another wheel with the same number of teeth and diameter, to which is joined a pulley, over which passes

a cord, chain, catgut, silken thread, or any other line or twist, which, being joined at both ends, is passed over another pulley fixed to the axle of the great wheel, which great wheel, when loaded with the aforesaid balls, turns round the aforesaid two other wheels, by which means the balls are lifted out of and from the fluids, and fall on an inclined plane or spout, which leads to the great wheel. At the lower end of this inclined plane or spout is fixed a small wheel, which is put into motion by spokes fixed on the rim or outward edge of the great wheel, which turns the balls separately on itself to continue the motion."

During the present century, there have been innumerable applications to the French Academy of Sciences for the appointments of committees to examine alleged inventions of perpetual motion; but, as is the rule in that body, the applications have been received, and a note made of the name of the applicant and the nature of his invention; and also, in accordance with the rules, the demand for a committee of examination has always been refused. There have also been many models of machines of the kind placed in the patent-office of this country; despite the number, there is no case on record in which one of them yet continues in motion, or ever has been in motion for any length of time.

It may not be known to everybody that the inventor of the rocket which bears his name, Sir William Congreve, not only believed in perpetual motion, but absolutely was of the opinion that he had constructed a machine which was self-acting. This was in 1827, at which time he published a pamphlet in which he described his machine, and at the same time demonstrated (to his own satisfaction) that it must be a success, although there is nothing on record to prove that it ever

did make so much as a single revolution. As is known, Congreve was a man of education and of a high intellectual grade. It may not be the fact that he ever constructed the machine which he advocated, having carried it no further than a demonstration on paper.

The present century has not failed to contribute its share of the folly connected with perpetual motion. In this country, and in England and France, there have been several hundred processes patented for machines self-impelled, and which are claimed by their owners to be capable of perpetual motion. It is somewhat singular that of all the thousand attempts which have been made, and recorded, and all the patents which have been issued, there is not a single machine in existence which is now running; nor is there any adequate proof that there ever was one that had life for a single instant. There is something remarkable in the fact that there have been so many patents during this century, as it is one in which all other departments of science have passed from the regions of the doubtful, the mysterious, the magical, into that in which everything is demonstrable. Some of the efforts of the nineteenth century will bear a detailed notice; if one can learn nothing else from them, one can at least discover that human ignorance still has a formidable existence, despite the light of knowledge which has so thoroughly inundated the world.

In 1801, William Parkes, of Newington, England, "Professor of Philosophy," patented a "perpetual power that will give motion to all classes of machinery, mills, engines, ships of war, mercantile vessels, lighters, crafts, and boats of every description." In brief, the invention of the "Professor of Philosophy" was very simple. Air was the power; air which is to be found everywhere, in the valleys, on the mountain-tops, above the plains, over the ocean, in the depths of the mines; hence it is

available as a motor wherever man may exist. Mr. Parkes evidently took the cheapness of air into consideration, and through his machine made a bid for the patronage of those who had to resort to steam, water, wind, or something of the kind to find power which would do their work. To use this air, he would first condense it, and then pour it out against the buckets of a wheel, as if it were a stream of water. This gave the motion; and when the wheel was in motion, by means of a crank it would work the bellows which condensed the air in the magazine. Probably nothing more stupid in theory or in practice than the machine of Parkes, "Professor of Philosophy," was ever devised or constructed.

In 1858, James Smith, of Liverpool, and Sydney Arthur Chase, of Liverpool, "gentleman," a firm evidently consisting of a capitalist and a mechanic—the one furnishing the brains, and the other the capital—entered upon the work of discovering perpetual motion. Between the years 1858 and 1865, they filed no less than five applications for patents for a perpetual motion machine, and various improvements connected with it. It is said by Dirck that the cost of these attempts was some ten thousand pounds sterling; and yet there is nothing to-day to prove that they succeeded in a single particular in accomplishing what they so assiduously sought for. Their machine was termed the "atomic engine," and was very elaborate in its construction, consisting of an infinite number of parts; and withal, was so intricate that an attempt to describe it without the detail drawings would be useless on account of its inevitable obscurity. The power to be used was compressed air; and in principle, the invention consisted of "certain mechanical appliances so arranged as to coöperate with the motive power of the atmosphere." Another form of their invention was the production of an engine which

should be self-acting, and whose purpose was to raise water above its level, the "fluids so raised to be the motive power." This was a very elaborate machine, and had but a single fault; it would not work. Then it was made still more elaborate and costly by the addition of "improvements," which made it still more complex, and imposing; and then it had but a single defect—it would not move.

In 1860, George Augustus Huddart, "gentleman," of Wales, patented something which presented some new features, in that it was not an attempt to make water turn a wheel to elevate itself, or a system of weights extended on one side and drawn in on the other side of a wheel. He announces it as a novel mode of applying the principle of buoyancy for obtaining a motive power. He describes it in detail as follows:

"For this purpose I set around the periphery of a wheel, or mount upon an endless belt or chain, a series of compressible air-vessels at equal distances apart, and these I connect together in pairs in air-tubes. The air-vessels I furnish with a weight which is free to move in parallel guides as the wheel which carries them rotates, and by its downward pressure the weight compresses the air-vessel to which it is attached, forcing the air through the air-tube in connection with the air-vessel to the air-vessel on the opposite side of the wheel, in which, at the same time, a vacuum is formed or being formed by the drag of its own weight, which is now attaining or has attained a pendant position. The apparatus I immerse in water or other liquid, and the expanded vessels being on one side of the wheel, while those on the other side are more or less in a state of collapse, will by their buoyancy move around the wheel and cause the collapsed vessels in their turn to expand and receive the air from the descending vessels, and thereby become the

ascending vessels or propelling power of the wheel. It will thus be understood that as the vessels attain a position in which their respective weights will act upon the air contained therein, and force it down the air-conductors, they will severally become compressed, and the vessels opposite thereto will expand and receive the air thus expelled; the vessels on the descending side, therefore, of the wheel will not expand until they attain their lowest position, and those on the ascending side of the wheel will not be compressed and have the air wholly excluded therefrom, until they have attained their highest position."

The year 1860 seems to have been fruitful for the production of perpetual motion machines, none of which present any novelties save the one just described, and one by Claude Joseph Napoleon Rebour, of Paris, engineer, who presents a patent for a perpetual motion in which gravity is the motive power. His description is very long, and obscure, so much so that it is useless to present it to the reader, for the reason that it cannot be well understood, the more especially that there is no explanatory diagram. In 1862, Reginald Courtenay, bishop of Kingston, Jamaica, patented an improvement in the obtaining of motive power, which consisted in the producing of motion by changing (increasing or diminishing) the specific gravity of an elastic fluid, the change being affected by revolving weights. Despite his rank, the bishop of Kingston, Jamaica, does not seem to have secured any especial success with his improvement; in fact, his process was a failure just as if the inventor had been a common engineer, "gentleman," mechanic, or capitalist.

And thus the patents are developed, many ingenious in conception, graceful in appearance, and satisfactory in every respect save one; and that one, the very one

for which they are constructed. The failures of all the centuries before do not seem to have any effect on the would-be inventors of perpetual motion of the nineteenth century. Nor does any special class seem exempt from the folly. In commenting on the men who have, during this century, taken out patents in England for perpetual motion, Dircks says they "consist of a colonial bishop, a professor of philosophy, and another of languages, two barons, a knight of the most noble and ancient order of the Temple, four military men, a doctor of medicine, a barrister, several gentlemen, two civil engineers, several mechanical engineers, a brass manufacturer, miller, mill-wright, smith, saddler, bobbin manufacturer, surveyor, a geologist, besides others whose professions are not named."*

The subject of perpetual motion has been pursued far enough to demonstrate conclusively, that it is an impossible attainment. The records of six centuries have been carefully examined; and in them there is not to be found a single authenticated case of a successful self-acting machine. The machine of Orffryreus is the only one that presents any claims worth considering; and in this instance there is no evidence that there was ever made an exhaustive examination of its parts with a view of discovering whether or not there might be some concealed spring, or other appliance for the generation of power; all the testimony is simply to the effect that those who saw it could find no connection with another room; they could walk all about it, and they could find no power outside of it. There is still other evidence in this case tending to strengthen the convictions of those who believe in the possibility of perpetual motion, and which would be of more value were it not that

* *Perpetuum Mobile.* Henry Dircks.

all other machines of the kind have been absolute failures.

In fact, it is so contrary to human experience, and so opposed by all the known laws of matter that any one is permitted to deny the success of the Orffryreus machine, no matter what may be the evidence favoring the genuineness of the result. If a dozen witnesses should testify that they saw a man lift himself by pulling at the straps of his boots, still the world would at once reject the evidence.

It is to be hoped that what has been gathered in this chapter in regard to the perpetual motion mania may satisfy some inventor that, if he chooses to undertake such a work, he will simply be doing that which has a thousand times been demonstrated to be impossible. There are abundant popular legends asserting that such machines have been invented, and that there are even now some in operation; and they do a vast amount of mischief; but they are not true; and the inventor who relies on them does so at the expense of his good sense, and if he goes further, at the expense of his time, his fortune, his reputation, and finally of his sanity.

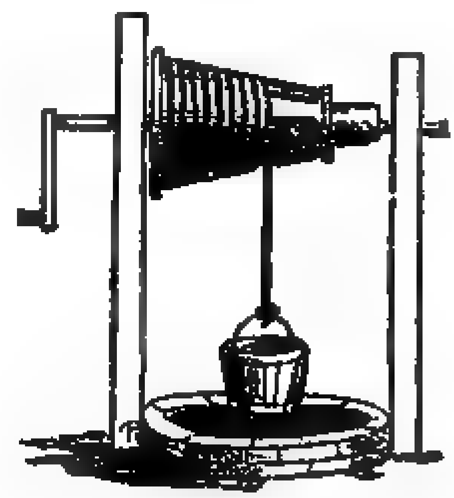
CHAPTER XV.

HYDRAULICS, HYDROSTATICS, ETC.

ABOUT the very first thing which the inventor among the primitive tribes found himself called on to produce was a machine for raising water, and of transporting it from points where it was to be found to others where it did not exist. From this simple problem at the outset, the improvements in methods of raising water continued until the steam-engine and the force-pumps of to-day. The advance of invention in this direction may be estimated by a comparison of the mussel-shell, or the hollowed gourd, or the leathern bag of the river-drift, or the stone ages, with which man elevated water, and the colossal machinery for the pumping of water which is in use in large cities. Men have had to drink water from all time; but as they advanced, and the cultivation of the ground was added to fishing and the chase for the supply of food, it was found that there were places and times where there was sometimes too much water, and sometimes too little. In the one case some method and machinery had to be devised to get rid of the surplus, and in the other to supply that which was lacking. Dipping up water with some hollow vessel was probably the first resort; in time, Archimedes furnished the nations with his screw for the raising of water, and this is in use even unto this day in some parts of the country bordering on the Mediterranean.

It was at first designed to aid the raising of water for the ends of irrigation. When the world began the digging of wells is only a supposition; but when they were in use, there was necessary some hydraulic machinery to raise the water to the top. We may get a hint as to what was done by the earlier races from that which is practiced among some of the primitive nations at the present time, who, in some portions of Africa, use the hollow bones of animals for buckets, which they lower into the water by means of thongs. From the string and the bucket, the ages advanced slowly; the string went over a pulley; then a bullock was harnessed to the end of the rope, and drew the bucket to the top. Then some Arkwright or Newton of these primitive days added another bucket to the other end of the rope, and thus came the double bucket system, one bucket going down empty as the other came up brimming from the cool depths. According to Pliny, the Romans used the windlass for the elevation of water; it is precisely the same windlass which is in use to-day in the mines for raising the ore and the dirt, and in so many places for lifting the material which is to be removed in the digging of wells. The ingenious Chinaman—like the modern Yankee, always in search of some method of doing things *easier*—discovered, or invented a modification of the windlass in which one-half of the roller or axle was considerably greater in diameter than the other half. The rope ran off the one and was wound up by the other, the weight to be raised or lowered sliding on, and suspended from the rope between them. As the crank turned the machine in one direction, the thicker diameter gave off the rope faster than the other took it up, and thus the weight was lowered; in turning it the other, the larger part took up the rope faster than the other payed it out, and thus the weight was elevated.

Sometimes some of the ancients had a big drum at one end of the windlass, and within its rim, there were little steps on which a man, or some other animal walked, and made the roller revolve, treadmill-wise.



CHINESE WINDLASS. FUSEE WINDLASS.

In some parts of the Orient, water is sometimes raised to extraordinary heights by a very simple process. A long gutter, or trough, is hinged to the banks of the stream: a native at the other end dips it in the stream, allows some water to flow in, when he raises the end till it forms an incline, and then the water pours out into a reservoir, whence, by a repetition of the same process, it is elevated to another reservoir, and so on to an unlimited height; the increase in each case, being about three feet.* There were modifications of this; and then the "sweep," yet so much in use in many of the farm-houses in the older-settled portions of the eastern states. There is in use among the Hindoos, a very ingenious modification of the sweep, which consists in constructing it so that a man can walk along the upper portion of it. There are hand-rails on both sides which prevent his falling off; he steps past the centre towards

* *History of the Hindoos.* Ward.

the bucket, and the end descends until the bucket reaches the water; then he passes towards the other end, which is weighted, and the rear descends, and the bucket is raised from the well.

HINDOO SWEEP.

Following these came various sorts of appliances in the shape of wheels whose outer rim bore buckets, which were filled as they descended into and rose from the water, and were emptied as they reached the top by being inverted over gutters for carrying the water away. There were scores of these various wheels, all different in their make, and all more or less efficient in carrying on the work for which they were constructed. The Romans had in use a system of raising water, which is very like the modern chain-pump. They ran double chains over an axis, at the height at which they wished to raise the water; and then ran the chains underneath

the water and beneath a fixed roller. To the chains they suspended buckets shaped like one-half of a cylindrical tin-can such as is used for the packing of preserved vegetables; the separation being lengthwise of the can. This gave a vessel twice or three times as long as its depth. The buckets rose from the water with their open surface up, and descended with them down.

ROMAN CHAIN POTS.

It was well along in the seventeenth century that the influence of the atmosphere became known. A "sucking" pump was made by a Florentine, which had no difficulty in raising water to a distance of about thirty-three feet; but beyond this it would not operate. It is said that the facts were submitted to Galileo, who gave the problem only a brief attention, and then said that it was owing to nature's abhorrence of a vacuum being limited, and ceased to operate above thirty-two feet. Some two years later, an Italian named Torricelli, announced that water was raised in a pump, not by any abhorrence on the part of nature to a vacuum—which had been believed

so many centuries—but by the pressure of the atmosphere. He demonstrated this fact by a long series of careful experiments which proved that the pressure of the air is equal to the weight of a column of water nearly thirty-three feet high, and of a column of mercury twenty-eight inches high. Torricelli, and his successor, who continued the experiments owing to the death of the Italian, drew upon themselves the anger of the Jesuits, who claimed to be the exponents of science, as well as the possessors of all scientific knowledge; but fortunately for the discoverer, nothing further than abuse was resorted to, for the reason probably, that there is nothing in the Scriptures which could be construed as being contradicted by this new enunciation of a scientific fact.

The demonstration was a very simple one. It was argued that if it were the atmosphere which produced the pressure, then there would be a variation at the foot and the top of a mountain. A Frenchman named Perrier, conducted the experiments, with the result that the conclusion as to the pressure of the atmosphere became established, and thereafter the air-pump became a reality. This was in 1651, and some five years later, in Cork, Ireland, Hooker, who was acting as an assistant of Boyle, invented the air-pump, and by its use he demonstrated the elasticity of air. The credit, however, of the invention is usually given to Boyle, but is claimed also for Otto Guerrichte of Magdeburg, and for Candido del Buono of Florence. It is also believed by many that the experiments made by Torricelli and his friends, in the use of mercury, to ascertain the pressure of the air, suggested the barometer.

Just when the atmospheric pump was discovered is not certain; probably for some time before the question was raised as to why water could not be raised over thirty-three feet by "suction." Industrious writers

fancy they find traces of it among the ancients, or claim that they must have had it, because they were so far advanced in other directions. There is proof that pumps were in use in the sixteenth century, and very soon they became very much varied in form, but all of them dependent on the atmosphere for their success. The force-pump came into use sometime during the latter portion of the seventeenth century. It was a great advance in the raising of water, for its operations were not limited to the thirty-three feet of the atmospheric pump; but by its use water can be raised to any height limited only by the strength of the materials of which it is composed, and the power applied in its operation.

The well-known stomach-pump is a forcing pump, and is claimed as the invention of John Read, an Englishman, in 1819. Concerning its first use the inventor wrote: "After visiting London twice for the purpose of getting some suitable tubes, and failing, I made a third visit, and succeeded in getting an indifferent one which I thought might answer, and then, after adapting it to the pump, I handed it to Sir Astley Cooper, who asked me for what purpose it was intended. I told him it was intended for the removal of fluid poisons from the human stomach; after a few minutes' inspection of the instrument, Sir Astley made the following reply: 'About three weeks ago I was called to attend a young lady about ten o'clock in the morning who had taken opium; I gave her sulphate of copper, sulphate of zinc, and other things: I sat by her until eight in the evening, when she died! If I had been in possession of this instrument at the time, I could have relieved her in five minutes, and have saved her life.' After many questions how I came to think of such a thing, which I satisfactorily explained, he said: 'What can I do for you?' My answer was, 'The publicity of

your opinion is all I wish.' He replied, 'That you shall soon have;' and he ordered me to meet him the next day at Guy's Hospital, at one o'clock, when he proposed to try an experiment on a dog; but as no dog could be procured that day, Sir Astley proposed Friday at the same hour; when I attended as before, the dog was then ready for the experiment in the operating theatre, which was crowded to excess. The dog was brought to Sir Astley, who gave him four drachms of opium dissolved in water. The dog's pulse was first at one hundred and twenty; in seven minutes it fell to one hundred and ten, and from that to ninety. The poison was suffered to remain in the dog's stomach thirty-three minutes, till he appeared to be dead, and I was doubtful it would be the case before Sir Astley would let me use the pump. I must confess I was very impatient to be at work on the dog, with my instrument in hand ready for action. Sir Astley kept his finger on the dog's pulse, then at ninety, and said very deliberately, 'I think it will do now, as it is thirty-three minutes since I gave him the dose.' A basin of warm water being then brought, Sir Astley passed the tube I had provided into the dog's stomach. I immediately pumped the whole contents of the basin (the warm water) into the stomach, and as quickly re-pumped the whole from the stomach, containing the laudanum, back again into the basin. Sir Astley observed, while I was emptying the dog's stomach, the laudanum swimming on the surface, and said: 'It will do.' A second basin of water was then injected and withdrawn by the pump as before. I asked for a third, but Sir Astley said it was unnecessary, as the laudanum had all been returned in the first basin." In half an hour the animal was completely revived, and running about the theatre.*

* *Pamphlet* by John Read. 1819.

There were various advances in the construction of pumps until the double cylinder forcing-pump was reached; a pump in which there were two cylinders, and from which the issue of the water was continuous. The first modern invention of this improvement was in 1716, by La Hire, a Frenchman; and as usual, in many of the inventions, the idea was borrowed from the ancients, having in principle been in use both by the Chinese—in the case of the wind-pump—and probably by other of the ancient civilizations. After this, there was no end to the varieties of pumps, there being lifting-pumps of all possible pattern; rotary-pumps of a dozen different kinds, some of which are in use in the modern steam fire-engines.

Up to this point, it will be noticed that all the efforts made for the handling of water have had reference to its elevation. They had been for raising it to levels where it could be used; from wells, to higher levels of land for the purposes of irrigation; to the upper stories of houses; and it is to this desire to secure machines for the raising of water that we owe the discovery of steam, or its application, as a motor. To get rid of the water in mines was a desideratum of the greatest value, and it was to this end that steam was first applied. This gigantic motor, which was destined to revolutionize the traffic of the world, was a regular development of an endeavor to improve machinery for the raising of water. This, however, will be treated of in full in another place.

One of the most important uses to which hydraulic machinery has been applied is in the water-works of cities, and in the operation of steam fire-engines. About the first hydraulic engines used in modern times for the supply of cities were in Germany, in about the middle of the sixteenth century. They were located in Augsburg. There is no description of the pumps used, but a writer

thus refers to the water-works: "The towers which furnish water to this city are also curious. They are near the gate called the Red Port, upon a branch of the Leck which runs through the city. Mills which go day and night, by means of this torrent, work a great many pumps, which raise water in large leaden pipes to the highest stories in these towers. In the middle of a chamber on each of them, which is very neatly and handsomely ceilinged, is a reservoir of hexagonal figure, into which the water is carried by a large pipe, the extremity of which is made like a dolphin, and through an urn or vase held by a statue sitting in the middle of the reservoir. One of these towers sends water to all the public fountains by smaller pipes, and the three others supply with water a thousand houses in the city; each of which pays about eight crowns yearly, and receives a hundred and twenty pretty large measures of water every hour." *

There are two systems of water-works in use; one in which the water is forced from some central point by machinery to all parts of the city using it; and the other is known as the gravity system, in which the water is collected in a reservoir located above the level to which the water is to be carried, or is forced by pumps into a stand-pipe high above the points where it is to be used, and from each of these the water is forced by gravity into the localities where it is desired. The gravity system is in use in the shape of reservoirs in the city of New York, and through the stand-pipe in the city of Chicago. The forcing system is known as the Holly, and is very economical in cities which cannot well afford the cost of reservoirs or stand-pipes. New York City uses about ten billion gallons of water per year,

* *Blainville's Travels.* 1705.

all of which is brought to the city from considerable distances through aqueducts and conduits. The Holly system has the advantage that the place employing it has no necessity for an expensive fire department; for the reason that, in case of a fire, the pressure on the water pipes at the central point can be increased in a moment so that each hydrant, through a hose, can throw water to the top of the highest buildings. In cities using this system, the fire department is limited to hose-cart, and hook-and-ladder companies. The system has also an advantage in the fact that the speed of the engine, and consequently the supply of water, is automatically regulated according to the demand.

Another class of water machinery is that which is used in giving motion, or for "power," as it is popularly termed. Of this there are several varieties, among which are the over-shot, and the under-shot wheels, and the various forms of the turbine wheels. The latter wheel is the invention of a Frenchman named Fourneyron; or at least he introduced it into France in 1827, and soon after Fairburn took it into England, and Boyden brought it to this country, Some English authorities claim Fairburn as the discoverer,* but there is no reason for concluding that he did more than to improve a machine which owed its existence to some other inventor. These wheels are very largely in use, their efficiency being rated from seventy-five to eighty per cent. of the power employed in driving them. They have many advantages over many other forms, in that they occupy but little room; they have a very high rotation; they do not require much gearing to communicate the motion, and may be used under almost all heights of fall without interference with their value.

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* *Industrial Biography*, p. 392. Smiles.

THE HOLLY PUMPING ENGINE (387)

Much value is gained from the use of water in hydraulic presses and the hydraulic ram, as well as in other directions. The hydraulic press is very simple in construction and principle, but very powerful in its action. In principle, it may be spoken of as as mall pump forcing water into a large cylinder, the latter containing a piston which is movable. As the water is driven in from the small pump, the piston of the large one is forced up with a force proportionately greater than its diameter is larger than that of the small cylinder or pump. This machine has many uses; the pressing of books, hay and cotton; testing the strength of steam-boilers, water-pipes, and in some instances, of cannon. Ships of the largest size can be raised out of the water by the power of this appliance; in fact, the limit of its strength is that of the materials of which it is composed.

The hydraulic ram is a very ingenious machine, and of the greatest utility in many directions, more especially in country places where the house stands on a height, and there is a stream near, and a demand that the water be brought up to the building. What is called an impulse-pipe leads from a cistern or reservoir, and is placed at an angle of about thirty-five degrees, or at such an angle of declination as may secure the amount of fall that may be desired. There is a bell-shaped valve at the lower end, which closes at the moment that the water comes rushing down through the pipe. There is a reaction towards the direction from which the water descends which, at a short distance from the lower end, forces open another valve opening up into a bell-shaped chamber, and into which the water rushes. This relieves the pressure against the lower valve, which opens, when the force of the stream closes it again, and the reaction of the water again opens the other valve, and the water is again forced into the chamber. This chamber connects

with a delivery pipe into which the water is forced, and carried to the point where it is needed. The chamber being filled with air, there is a constant, instead of an intermitting stream, through the delivery pipe, for the reason that the upper portion of the chamber is filled with air, which is compressed when the water rushes in through the valve, and whose expansion keeps a steady pressure on the water, and thus secures an unbroken flow.

The steam fire-engine of to-day has very few points in common with its primitive ancestor, or the machine which was employed for the extinguishment of fires. At the beginning, buckets were probably used, but as these could not be of service in reaching any height, some other device had to be resorted to. The fire-engine of the ancients has been alluded to in another place; the first fire-engine used by the moderns was a *syringe* which was introduced into London, in the latter part of the sixteenth century. Hook, ladders and buckets were the only things in use before the syringe came on the stage; and beyond doubt, it was hailed, on its advent, as being the *ne plus ultra* of invention in that direction. These fire-engines usually held from three to four quarts; they were from three to four feet long, from one and a half to two inches in diameter, the nozzle being reduced to an inch. Three men were required to work one of these machines; two held it by handles, dipping it into a bucket when empty, and directing it against the fire when charged, while one man agitated the piston. This engine had one advantage over the modern appliance, it had no other; it did not have to have a pair of horses hitched to it; when there was an alarm, a fireman took the machine under his arm, another man caught up the cistern; there was no time lost in making connections with the hydrant; and there was a stream on the blaze in an incredibly short time.

It is not probable that the fire was ever extinguished, unless no larger than that of a match; but the house and its contents were not ruined by an inundation of water; and in these respects the ancient syringe had its advantages over the fire-engine of to-day. The next improvement of the syringe was to mount it on a pair of wheels, and to increase its size. In this improved shape it had the appearance of a huge sausage stuffer. The piston

SYRINGE FIRE-ENGINE.
(From Besson. A. D. 1568.)

was a screw which fitted threads cut on the inner side of the cylinder; and there was a crank at the end of the screw which was turned, and the screw was forced in, driving the water before it, and out through the nozzle in quite a formidable stream. When the water was all driven out, the piston was screwed back, a stop-cock near the nozzle was opened, a funnel was inserted, and another fireman filled the syringe with a bucket, on the end of a stick, taking water from a tub at his side which was kept filled by the bystanders. When it was necessary to change the direction of the stream, the entire machine had to be shifted to meet the new requirement. This machine came

into use in about 1568, and is known as the syringe engine.*

This was a vast improvement on the original syringe; it held a barrel of water, could be raised or lowered, or moved to the right or left in order to secure a needed change in the direction of the jet. It was cumbersome; there was considerable time lost while the attendant refilled the emptied magazine; but still it was so much of an advance over its predecessor that it demonstrated that invention was at work, and getting ahead famously considering the period in which the labor had to be done.

In 1615, pumping fire-engines were in use in Germany. They were very rude and primitive, being a wooden tub with a cylinder, and a single piston which was operated with a long lever which men lifted up, and bore down, admitting the water into the cylinder, and then forcing it out through a short bit of hose and a pipe. It was placed on a sled, and was dragged to the fire by means of ropes. This machine did not supplant the squirt in England till some twenty years later. The great fire occurred in London in 1666; and at that time the "engine" and the hand-squirts were still in use. Maitland mentions some ordinances of the common council in which certain householders were ordered to provide themselves with implements to be used in case of a fire,

* Propositio de 'l Autheur: Artifice autant singulier (comme je pense) que non point commun, pour jecter l' eau contre un grand feu, mesmement lors que pour la grandeur de la flamme, nul peut entrer ny approcher de la maison qui brusle. *Declaration de la figure:* C' est instrument, qui est faict en forme de Cone, se son soustient sur deux Roues; ayant sa bouche tournée vers le septentrion; et aupres de sa base il y a des demicercles, qui servent a l' hausser, au baisser, d' avantage vers sa dicte bouche septentrionale est un Entennoir, pour y verser l' dadans; et en sa base, ou bie, partie meridionale, est une vie, dont est poussée dedans et recule un Baston auquel sont des Estoupps ainsi qu' aux siringues. Le reste appert. Besson's *Theatre.*

AMERICAN STEAM FIRE-ENGINE.

(948)

and in which hand-squirts are particularly mentioned, and ordered as a part of the outfit. In 1739, Strasbourg had a fire-engine with two pumps, which were a rude imitation of the modern brake-machine, with the difference that, in place of the brakes, there were two levers which were operated like the handles of a pump. This was in the first half of the last century, and at this time hose came into use, and not very long after, the value of the air-chamber was discovered; but it was not till the early part of the present century that the hand-machine was introduced; and which continued with little alteration until replaced by the "steamer." It may be added that the "hand-machine," or the one which is operated by brakes, is still in use in many places too small to own a steam fire-engine; and even in the great city of London, small hand-engines are still kept, and are started to a fire on its first being signaled.

Fire-engines were first introduced in this country in 1730, being of the pattern known as the Newsham machine, an English invention. They arrived in New York in December, 1731; and the first fire company was legally organized in 1738. In 1840, the first steam fire-engine was manufactured in this country, being designed by Mr. Hodges, according to some authorities, and according to others, by a European engineer named Ericsson; but in any case, although about the last of the great nations to use steam as an agent for the extinguishment of fires, this country now is incomparably superior to all others in its "steamers" and the personnel of its organizations. The city of Chicago has undoubtedly led all other parts of the union in the direction of improvements in the management of fire apparatus. Its men and horses are so well trained that it is regarded as a very inefficient company that will not within fourteen seconds after an alarm of fire, take its horses from their stalls, hitch

them to the machines, and drive out of the building. In the make-up of a department of the fire system, there is what is known as the fire-patrol. A thousand times have the men connected with the fire-patrol wagons, been placed in bed, over the room in which the wagon is stationed, and within *four* seconds from the first stroke of an alarm, have their horse hitched to the wagons, themselves all in their seats on the wagon, and the hind wheels of the machine crossing the threshold.

This celerity is so very remarkable that it is very difficult to believe it unless one sees it.

Some of the American fire steam-engines are self-propelling. A good steamer can throw water to the height of nearly one hundred and fifty feet, and on a level to a distance of two hundred and fifty feet with an inch and three-quarter nozzle; or with an inch and a quarter nozzle, will throw a vertical stream two hundred and twenty feet, and horizontally a distance of over three hundred feet. In the Chicago engine-houses the water is always kept hot by steam circulated through it from a boiler below; and a light so arranged that as the engine moves out in response to a call for a fire, a gas flame ignites the kindling in the fire-box so that in a gallop of a short distance, steam is up and the engine ready for operation when it reaches the locality of the fire.

Apropos of appliances for the extinguishment of fires, there are several chemical machines, which operate by the liberation of a gas in which combustion is impossible. Among these, the Babcock is the most famous; which, with all others of the kind, is too well known to require detailed description.

It may be said of the use of hydraulic machinery that it has been always substantially in the interests of peace. There are no blood stains on it from the earliest record of

its existence. It has been pastoral in its tendencies, taking kindly and naturally, as it were, to the peacefulness and simplicity of country life, where it has leagued itself with the industries which are most intimately connected with the support of life. It is to be found on remote streams, in the depths of the country—the whirr of its revolutions mingling harmoniously with the splash

BABCOCK CHEMICAL FIRE-ENGINE.

and the rush of the waters—engaged in changing the products of the golden wheat fields, or the yellow tasseled corn into healthful food. It is a frequenter of the primeval forests, where it goes to assist the pioneer in his effort to clear the land for cultivation by affording him the lumber with which to build a shelter, and the barns in which to store his products. It speeds the spindle and drives the looms which give men garments

to protect them from the cold, and carpets with which to make comfortable, or to decorate their homes. Its economy places it within the reach of the poorest communities; it is harmless as it is potent, for unlike steam, it carries no element of destruction in its composition which may at any moment explode, and impose death or torture on all within its reach.

In all its relations and its aspects, it is beneficent, laboring mainly to supply the needs of the human family, having no agency in the construction of implements for the destruction of life. In the great cities, where there are water-mains, it drives the sewing machine, and assists in a thousand ways in carrying on the simpler, but always necessary industries connected with every-day life. It is always simple, unpretentious, philanthropic, tireless in its labor, faithful to its mission, and apart from the more showy of the harnessed energies of modern life. It requires no monumental stack to indicate its locality, and to pretentiously point out a fussy existence. Quiet, retiring, it works while life lasts, and does its labor conscientiously and well.

CHAPTER XVI.

THE SPINNING-WHEEL, LOOM, ETC.

THE term spinning-wheel may very properly stand as the type, the representative of the grandest industries known to the modern world. It is the successor of the distaff, and the predecessor of the spinning-jenny, the marvellous power looms, the colossal cloth manufactories of the nineteenth century.

It is less than half a century since the spinning-wheel was an honored resident of every household of every farmer not close to some city. The sheep were reared on the farm; they were washed, sheared, and the wool was sent to the mill to be washed again, to be carded into rolls, and in that shape sent back to the farmer's home. Then the spinning-wheel commenced its merry winter's song; the long rolls of wool were spun into thread; and this, in the family loom was woven into cloth, and then dyed and made up into homespun for the wear of the family. Even to-day, there are innumerable families, remote from the centres of trade and commerce, who have their own spinning-wheel, their looms, their own dye-pots in which, with the brown extract of butternut, the cloth for the family wear is prepared for the scissors and the needle to be fashioned into garments.

There came a time among these people when there appeared on the scene an article known as "cotton-yarn," and this gave a new theme to the busy spinning-wheel,

which it sang through winter and summer. This cotton-yarn consisted of skeins composed of very fine threads. It was the mission of the younger members of the family to "wind" this "yarn," which consisted in uniting the thread of several of the skeins into one thread, and winding them into balls. Then some of the older members, the largest girl generally, who had

A LOOM OF THE EIGHTEENTH CENTURY.
(From "The Two Apprentices." Hogarth.)

reached the age sufficient to guarantee her judgment and integrity, was assigned to the important task of "twisting" the balls into a single thread in which were united those which had been wound off on the balls. As fast as the spindle was filled, it was reeled off into other skeins; and these were taken off on spools, this by one of the youngsters. Then the grand genius of the

female head of the house was needed to carry the thread to its further destination. All the contents of the spools were wound off on the "warping-bars," and now appeared like a huge cable, whose length was equal to the number of yards required in the "piece." Then it was carried to the loom, and slowly wound around the great roller till the ends were reached; when each end of all the threads was "handed in," and then the work of the weaver was ready to begin. The wool that had been spun and reeled into skeins was now wound on the tiny spools, and these were placed in the shuttle. And now the weaver began her work. The swift shuttle flew between the threads of the warp as if through open jaws; the treadles under the feet of the weaver, reversed the threads of the warp, closing tightly on the woolen thread, or "filling," which had just been run through, and opening their capacious jaws for another mouthful; and thus on till cotton-warp and woolen-filling became as united as if grown on the back of some living animal.

The man who has in his memory the pulsatile clang of the beam that drove the woolen threads home, the swift whirr of the revolving spool of the shuttle as it unwound its treasure and delivered it to be buried in the voracious woof; the song of the weaver as the shuttle flew to the right and the left, beating the time of her music; the concentrated hum of the spinning-wheel as it twisted or spun, interspersed with the foot-falls of the spinner, has something than which no music of Meyerbeer, or Beethoven will awake more tender recollections, or arouse more acutely the flagging sensibilities. Age may impair the later occurrences of life; but these, unlike as they are all that modern life affords, will cling with tenacity proportionate to the lack of anything in these days to suggest them.

SPINNING—THE OLD AND THE NEW WAY.

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The old family spinning-wheel was a poem of the household. It sang, in the winter evenings, of the future; of weddings to come as it spun the garments to be worn; of cloths that were to be worn by the boy that was about to venture out into the broad world; of expected comfort and certain sorrow; and it hummed low memories of the past as it recalled those who had so often marched sentinel-like in front of it, but who now were silent and motionless for ever. Glorious old spinning-wheel! It deserves to be canonized! A thousand things there were among ancient nations which, for far less service, were classed as divine, and received the honors to which they were entitled by their elevation into the ranks of the sacred.

The origin of the spinning-wheel is lost somewhere in the past; but it probably had its birth in the Orient, where the making of cloth was known long anterior to its introduction into Europe. Cotton cloth or calico, and muslin, both came to the European peoples from India. The authorities place the introduction of the spinning-wheel into England during the reign of Henry VIII., previous to which time, all the spinning had been done by the distaff and spindle. A mass of cotton fibre was attached to the forked end of a stick, and the thread was twisted by the fingers, and when a small length of it was finished it was wound on a spindle. It was not till the eighteenth century that there was any improvement over the spinning-wheel; and this improvement was made by an Englishman named James Hargreaves, producing what he called the spinning-jenny. The main difference between it and the spinning-wheel is that his jenny spun eight threads at once, in place of one. Eight spindles were set in a frame, and made to revolve; the operative carried in his hand a wooden frame of two pieces, the upper closing on the lower and clasping

between them the eight rolls to be spun. This was in 1765, at a time when there were no cotton mills or woolen ones known; but the wool to be spun was given out to the operatives to be done on the spinning-wheel at their own homes. Hargreaves, after the invention of his jenny, turned out so much yarn that the other operatives became alarmed, and broke into his house, discovered his secret, and at once smashed his machine, which had, at that time, grown to a much larger number of spindles. He was a poor working-man, but he was not discouraged by his unlucky beginning. He went to Nottingham, secured some financial assistance, built a small mill, and began the spinning of yarn by his process, in which he was very successful; but, about this time, Arkwright, in 1769, produced his mule, which was improved by the incorporation of some of the ideas of Hargreaves, and which was subsequently improved until about 1785, when it was considered completed. It was at first driven by water-power, and then by steam; and in its completed form is ascribed to some English writers as the work of Samuel Crompton. "The cotemporaneous inventions of Hargreaves and Arkwright, though at first encountering violent opposition, in conjunction with the invention of the mule, a few years later by Samuel Crompton, united to bring about speedy and important changes in the process of cotton spinning, and have since given to this branch of our national industry a development which has been the wonder and the admiration of the world. This remarkable progress is, of course, also to be largely ascribed to the invention of the steam-engine." *

In order to give all the credit due under the circumstances, it is but proper to add that there are several

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* *British Manufacturing Industries*. Bevan.

other claimants to the honor of the invention of the spinning-machine, among whom are Paul, Wyatt, and

MODERN SPINNING MULE.

Higley. That Crompton did make some valuable improvements in the spinning-machine may be fairly

allowed; he took the machines of Arkwright and Hargreaves, and eliminated some of their faults, for which he was rewarded with a pension of twenty-five thousand dollars by the British government—although not till some thirty-three years after he had produced his spinner.

Arkwright has a name far better known than that of any of his competitors. His history is a curious one. He was born in England in 1732, and was the youngest of a family of thirteen children. He was apprenticed to a barber, learned the business; ran a shop for a time on his own account; and, then, as "trade" became dull, he entered on the business of traveling about the country buying up human hair. He followed this for awhile, and then tried his hand at the problem of perpetual motion; and soon after, in response to a general demand for the improvement of the process of spinning, he, in common with many others, began a search in the popular direction. Like the majority of inventors, he grew poor in his search, and lost at once all his money and his friends; and to crown his misfortune, his wife, who was opposed to his spending his time in this useless pursuit, broke all his models during his absence one day from home. He left her, and continued his search, with the result that by the aid of a friendly mechanic he was able to design a machine and construct a model. He put his model on exhibition, but was so ragged and dirty, that some sympathizers subscribed enough money to enable him to make a creditable appearance. He was forced to leave Preston owing to the menaces of the operatives in the vicinity, and went to Nottingham, where he found a friend in a banker named Strutt, himself an inventor; and in 1769 the improvement was patented. It did not, however, work at once, nor in fact, did it till several years later; and then success was won

only through an opposition which would have disheartened a man less persevering than Arkwright. A mill that he erected was destroyed by a mob of working-men, inspired by the old grievance that his machine was an injury to working-men, by doing what it required many hands to do under the manual method. Other manufacturers found that his superiority was injuring them, and they then undertook to crush him by refusing to buy his products, although superior to all others in the market. They also refused to pay for the use of his patents, and combining, they fought him in the courts, and for a time broke down his patents.

He refused to yield, and fought doggedly on, with the result that in a few years he had succeeded in becoming the largest mill-owner in that region, and controlled the markets by the superiority of his work. He became very wealthy, and was knighted by George III. He died in 1792. In many respects he was a most wonderful man, especially when it is considered that he knew but little of reading till after he was fifty years of age, at which period he studied English grammar, and improved himself in writing and spelling. Before he became a mill-owner of prominence, it had been the custom of the owners to have the various branches of their work performed at different places. Sir Richard Arkwright introduced the modern system of the factory, in which all is done under a single roof. It may be that in this movement he increased the value of the labor which he employed; but it is certain that he did it at the expense of the health, morals, and comfort of the operatives. There have been some ameliorating features introduced of late; but taken as a whole, the modern factory system is, next to African slavery, one of the most disgraceful blots of civilization. The infamous cruelty practiced by the employment of young children has had

the effect to give us a race of people scarcely human in their developments.

While it is true that Arkwright was the first to employ his operatives in masses under one roof, he cannot very well be held responsible for its results. If he had not initiated the system, some other one would. It was an outgrowth of the times; its introduction was not a question of men, but simply of the occasion.

RING SPINNING FRAME.

The machine perfected, or improved by Crompton, is substantially the one in use in spinning at the present time, except that where he had some twenty-five or thirty spindles, those now in use have often from fifty to seventy times as many. This machine is automatic. The carriage with the spindles recedes from the roller holding the material to be spun; the thread is stretched to the proper length; twisted the requisite number of times; and the carriage with the spindles returns to the

place whence it started, the spun thread being taken up and wound on a cop on the spindle. Previous to the invention of the mule, few spinners could make yarns of two hundred hanks to the pound, the hank being always eight hundred and forty yards. The natives of India were at the same time making hanks of numbers varying from three hundred to four hundred. By the best constructed mules, yarn has been made in Manchester of number seven hundred, which was woven in France.*

We have now reached a period in the history of spinning in which arrangements have been completed for an unlimited supply of spun yarn, and which fact will suggest to any reader, that two other things are essential to the economical employment of all the facilities in use for spinning; these two being an ample supply of the raw material, cotton and wool, and looms with which to weave the products of the spinners. At the time when Crompton, Arkwright, and the others had completed their improvements, the means for the supply of cotton, for instance, were only equal to the comparatively moderate demand which had before existed.

In 1793, a period substantially cotemporary with Arkwright and Crompton, an American invented a machine for separating the seed of the cotton from the fibre, which process had hitherto been performed by hand. In 1791, the cotton crop of the Southern States was two million pounds; in 1801, Whitney's cotton-gin was in operation, and the product of the same area was nearly fifty million pounds, the increase being largely due to the invention of this machine. Here was a case—seen so often before in these pages—in which an invention came in response to an urgent demand. If Eli Whitney had not met the want, there is no reason for doubting

* *Mechanical Progress.* Edward H. Knight.

that it would have appeared about the same time, and would have conferred immortality on some other name. Before the invention of the gin, it was the labor of a day for one hand to pick a pound of cotton from the seeds; the Whitney gin ran the amount which could be cleaned by the machine to over three thousand pounds. This was the solution of the problem which had been formulated by the inventions of Arkwright and others, of the

EAGLE COTTON-GIN.

spinning machines; the cotton-gin settled the question of supply; and there only remained the other problem relative to the looms for the disposition of the products of the spinners.

Before touching on this, a word may be said of Whitney, who thus solved a problem whose importance cannot be over-estimated. He was born in Massachusetts, in December, 1765, and died in Connecticut, in January,

1825. He was a graduate of Yale College, and a graduate in law in Savannah, whither he went after leaving college. His attention was called to the tedious process of separating the green seed from the cotton, and he applied himself to discovering means of doing the same work by machinery. He had no facilities for work, having to manufacture the tools with which he worked; but he accomplished what he labored for. When he had about finished his machine, some rumors got abroad as to what he had done, when the house where he had the machine stowed away was broken open, and the machine was stolen. Soon after, the same kind of a machine was put in use in various parts of South Carolina. He finally secured his patents, but they were incessantly infringed on. He was voted a gift of fifty thousand dollars, which he only gained after a vast deal of trouble and litigation. He had an arrangement with the state of Tennessee; but that state failed to keep its contract in a single particular, and had the benefit of his invention for nothing. His troubles were so great, and his labor so arduous in securing from the South compensation for the use of his machine, that he finally gave the whole matter up in disgust, and turned his attention to manufacturing arms for the government. He was the first who constructed small arms in such a manner that every piece in one gun would exactly fit the same place in every other gun.

The art of weaving is one of the oldest of which we have any traces. Remnants of woven material have been found in the Swiss Lake dwellings, in the graves of Egyptians, and in other places having an ancient origin. Weaving is mentioned in the Bible in various places, as when allusion is made to "curtains of fine-twined linen, and blue and purple, and scarlet," to the "vestures of fine linen" in which Joseph was arrayed by Pharaoh, and to "days that are swifter than the weaver's shuttle, and

are spent without hope," by Job. As the periods in which these references are made are located several thousand years in the past, it is very evident that the art of weaving was then understood; and had we not this evidence, there is still enough to be found in the remnants left by other ancient peoples. The new tribes who have become known to us of late, and who are yet in a condition of savagery, all have some form of weaving at their command. In some instances, grass is the material used; in other cases a species of bark is made into cloth; and in others, it is found that among the ancients, and modern savages who have no other knowledge of weaving than such as they developed among themselves, a large number of substances have been and are used, such as sheep's wool, the hair of goats and camels, silk, flax, hemp, cotton, gold, silver and asbestos —the last-named article being used for lamp-wicks and cremation.*

Some of the looms seen by Mungo Park in Mandingo were exactly like the English looms, but so small and narrow that a web was not more than four inches wide. The women prepared the cotton for spinning, and the men did the weaving. The ancient Egyptians wore woolen and cotton clothing and linen, the latter being worn by the priest on account of its superior purity, "for they were not allowed to enter the temples with any article of dress composed of wool, and on no account were they allowed to wear it for under-clothing, that material being considered unclean, owing to its property of breeding, or being liable to become infested with, worms and insects." †

It is thought that it is owing to the excellence of the linen in which the Egyptian mummies were enshrouded

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* *Textrinum Antiquorum.* Yates. † *Ibid.* Yates.

that they have remained so well preserved for more than a score of centuries. "It was from this circumstance that what actual knowledge is now possessed of Egyptian weaving is owing, and the preservation of numerous specimens found in the mummy pits of Europe. Linen was chosen to enshroud the dead on account of its cleanliness, and its lasting qualities. The dead were encased in its folds so that the bodies should be preserved uninjured, for a space of three thousand years, when it was believed the former spirit would return after its transition state and habitation of the bodies of various animals, to resume its former existence." *

After the tenth century, weaving made some progress in various parts of the continent of Europe, and among some of the Oriental people, specimens of whose work are to be found in various museums in the capitals of Europe. It is about the tenth and eleventh centuries that weaving began to assume any prominence in Europe; and so far as is known the first weavers were Flemings who commenced operations in the tenth century, and furnished the most of the woolen goods used in the other parts of Europe. In the thirteenth century, Spain entered the field, and was able to furnish cloth that at once took high rank in the European markets. At about the same time woolen manufactories were established in Florence which produced annually one hundred thousand pieces of cloth. Long anterior to this, according to English authorities, weaving was known in England to a very great extent; but it was to the Flemings that was owing the excellence which the English weavers attained at a later date. It is claimed that it was introduced to the Britons by the Romans, and that it was carried on and improved during the

* *Ancient Egyptians.* Sir G. Wilkinson.

Anglo-Saxon occupation. Among the Anglo-Norman ladies there was developed a good deal of skill with the needle, to which fact the world owes much of the beautiful tapestry of that period. It was at this period that the famous Bayeux tapestry was made, and the work is popularly attributed to Matilda, the wife of William, the Norman conqueror; but other authorities assert that it was done by English hands in London by order of one of the three knights who came from Bayeux.*

During the reign of the Conqueror, a large number of Flemish weavers came over to England, and thereafter, the great wool manufacturing interests of England were established. It was during the reign of Edward III., in about 1340 to 1353, that England established its supremacy in the making of woolen cloth. Some three hundred years later, Fuller alludes to this period in a paragraph whose quaintness and odd information entitles it to be quoted:

"The king, observing the great gain to the Netherlands by the export of wool, in memory whereof the Duke of Burgundy instituted the order of the Golden Fleece—where indeed the fleece was ours, the gold theirs—so vast was their emolument by the trade of clothing. The king therefore resolved if possible to reduce the trade to this country, for Englishmen at this time knew no more what to do with the wool than the sheep which wear it, as to any artificial or curious drapery, their best clothes being no better than friezes—such their coarseness from want of skill in the making. Unsuspected emissaries were employed by our king in those countries, who wrought themselves into familiarity with those Dutchmen as were absolute masters of their trade, but not masters of themselves, as journeymen

* Rev. D. Rock.

and apprentices; these bemoaned the slavishness of these poor servants, whom their masters used rather like heathens than Christians—yea, rather like horses than men; early up and late in bed, and all day hard work, and harder fare, as a few herrings and mouldy cheese, and all to enrich the churls their masters, without profit to themselves. But, oh, how happy should they be if they would but come to England, bringing their mystery with them, which would provide their welcome in all places! Here they would feed on fat beef and mutton till nothing but their fullness should stint their stomachs. Yea, they should feed on the labors of their own hands, enjoying a proportionable profit of their gains to themselves: their beds should be good, and their bed-fellows better, seeing that the richest yeomen in England would not disdain to marry their daughters unto them, and such the English beauties that the most envious foreigner could not but commend them. Many Dutch servants left their masters and brought over their trade and their tools, such as could not be made in England; and happy the yeoman's house into which one of these Dutchmen did enter, bringing industry and wealth along with them. Such who were strangers within, soon after went out bridegrooms and returned sons-in-law. Yea, those yeomen in whose house they harbored soon proceeded gentlemen, gaining great estates to themselves, arms and worship to their families. The king sprinkled them throughout the country, though, generally, when left to themselves, they preferred a maritime habitation." *

When England had discovered the great value of the woolen manufactories, she took the greatest pains to prevent anything which was thought to be injurious to

* *Fuller's Church History.*

stand in their way. Out of this jealous guardianship there grew a term which is in common use, but whose origin is not generally known. Laws were passed to prevent the exportation of wool, and on the seat of each member of the House of Lords there was placed a sack of wool to keep him in incessant remembrance of the value of the trade which the wool represented. Hence the term wool-sack. Then as now in England, the judges sat on the wool-sack; in this country, the term has no reference to a bag stuffed with wool; but the wool-sack is used to indicate the judicial seat. The word appears in some of the parliamentary acts with reference to the seats which shall be occupied by the members.*

In 1519, cotton was discovered by Magellan in use among the Brazilians, and not long after the use of this "vegetable down" became known to the English, and its manufacture was entered upon. In 1558, an act was passed by parliament which will suggest that there is nothing new under the sun. That making "shoddy" is not, as many have supposed, a modern invention may be inferred from the act in question. It says: "Certain evil-disposed persons who buy and engross great store of linen cloth, do cast the pieces of cloth over a beam or piece of timber made for their purpose, and do by sundry devices rack, stretch, and draw the same both of length and breadth, and that done do then with battledores, pieces of timber and wood, and other things sore beat the same, ever casting thereupon certain deceitful liquors mingling with chalk and other things, whereby the said cloth is not only made to seem much thicker and finer to the eye that it is indeed, but also the thread thereof being so loosed and made weak that

* *Notes and Queries.*

after three or four washings it will hardly hold together, to the great loss and hindrance of the natives." Following this comes a clause forbidding these practices. The evil was so serious that not only was the practice thus taken up and forbidden by act of parliament, but it was made the occasion of sermons of denunciation from the pulpit. Among others, the celebrated Latimer denounced it roundly, especially that portion of the process in which by the use of "flock powder" or chipped wool, the thickness which the cloth had lost by the stretching and beating was restored. Some method of incorporating this material was employed which made the cloth seem of greater thickness than it was when originally woven.

In 1621, cotton was planted in this country; but there was but little shipment of it till after the war of the Revolution. In a little more than a century after having been planted, the crop amounted to forty-eight million pounds per annum; it has since in a single year reached the dimensions of one billion eight million pounds; in fact, even this extraordinary amount has been exceeded in certain favored years, as notably in 1859–60, when the total crop ran above two billions of pounds.

Up to the period now under notice, weaving was all done by hand. A large portion of the products of the spinning-machines was sold as yarn to dealers who resold it to families, by whom it was used as described in the opening of this chapter. Such a thing as a power-loom was not known. The first spinning-machine put up in this country was one of Arkwright's, which was brought over, and erected in Providence by an English operative named John Slater. This was in the year 1790; and it was not till some twenty-two years later, in 1812, that the first power-loom was constructed. It

was the invention of Francis C. Lowell, of Boston, who had spent some time abroad, and had there obtained some suggestions of the power-loom, which had at that period been introduced, and was in operation in England. The loom was erected in Waltham, Mass.

KNOWLES LIGHT FANCY POWER-LOOM.

The first power-loom for the weaving of wide cloth, as a practical result, was made by an Englishman, Dr. Edmund Cartwright, in 1787. There had been various attempts to reach this result, made long before the success of Cartwright. More than a century before, a Frenchman had invented what was called a "A New

Machine for Making Linen Cloth without the aid of a Workman," which was described in the *Journal des Savants*, in 1678; but it does not appear that it ever came into use. In 1745, Vaucanson, a Frenchman, constructed a self-acting loom; in 1774, another self-acting loom was produced by Robert and James Barber, of Nottingham, England.

The loom invented by Cartwright is probably the first which fully answered the purpose for which it was constructed. The fact that the inventor was not a mechanician in any sense of the word, but a clergyman who had never given the smallest attention to practical mechanics, makes him and his invention worthy of some special notice. He was born in 1743, at Marcham, Notts, England, of an old family. He attended University College, Oxford; became a clergyman, and till 1779, he devoted himself to the duties of his calling, and to literary efforts. It was in 1784 that he suddenly took to invention, and for reasons which are sufficiently curious to permit the publication of a letter written by him to a Mr. Bannatyne, and in which he explains his sudden change from a cleric to an inventor.

"Happening to be at Matlock in the summer of 1784, I fell in company of some gentlemen of Manchester, when the conversation turned on the Arkwright spinning-machinery. One of the company observed, 'That as soon as Arkwright's patent expired so many mills would be erected, and so much cotton spun, that hands never could be found to weave it.' To this observation I replied, that Arkwright must then set his wits to work to invent a weaving-mill. This brought on a conversation on the subject, in which the Manchester gentlemen unanimously agreed that the thing was impracticable; and in defence of their opinion they adduced arguments which I certainly was incompetent to answer,

or even to comprenend, being totally ignorant of t subject, having never at any time seen a person wea' I controverted, however, the impracticability of t thing, by remarking that there had lately been exhibit in London an automaton figure which played at che: 'Now, you will not assert, gentlemen,' said I, 'that it more difficult to construct a machine which shall wea than one which shall make all varieties of moves whi are required in that complicated game?'

"Some little time afterwards a particular circu: stance recalling this conversation to my mind, it stru me that, as in plain weaving, according to the conce tion I then had of the business, there could only three movements, which were to follow each other succession, there would be little difficulty in produci: and repeating them. Full of these ideas I immediate employed a carpenter and smith to carry them in effect. As soon as the machine was finished, I got weaver to put in the warp, which was of such materi as sail-cloth is usually made of. To my great delight piece of cloth, such as it was, was the produce. As had never before turned my thoughts to anythi: mechanical, either in theory or practice, nor had ev seen a loom at work, or knew anything of its constru tion, you will readily suppose that my first loom was most rude piece of machinery. The warp was plac perpendicularly, the reed fell with the weight of least half a hundred weight, and the springs whi threw the shuttle were strong enough to throw a Co greve rocket. In short, it required the strength of tv powerful men to work the machine at a slow rate, a: only for a short time. Conceiving in my great simpl ity, that I had accomplished all that was required, then secured what I thought a most valuable proper by a patent—April 4th, 1785. This being done I th

condescended to see how other people wove; and you will guess my astonishment when I compared their easy mode of operation with mine. Availing myself, however, of what I then saw I made a loom, in its general principles nearly as they are now made. But it was not until the year 1787 that I completed my invention, when I took out my last weaving patent, August 1st, in that year." *

In speaking of the invention of Cartwright, Knight says: "The justness of his claim to the power-loom may be appreciated when it is stated that his loom, patented in 1787, has automatical mechanical devices to operate all its parts." Having once given his genius to invention, the reverend gentleman seems to have become infatuated with his new pursuit. In 1791, he took out patents for metallic packing to the piston in the steam-engine, and soon after he patented a combing-machine. He also invented bread-making and brick-making machines, and also some improvements in rope-making. He expended some thirty thousand pounds sterling in an attempt to establish a spinning and weaving factory in which all sorts of mechanical experiments could be carried on; but which was a failure after an existence of some nine or ten years. He made a contract at Manchester for the use of four hundred of his looms which did their work well, but, with the factory, were burned by a mob of weavers who thought that the new weaving-machines would deprive them of their employment. For all that he had done for the advancement of weaving, he received a grant of ten thousand pounds sterling from the English government.

It has been seen that, in the cases of two or three of the characters which have been referred to, each inventor

* *History and Principles of Weaving.* Alfred Barlow.

of an improvement, or of some appliance for use in manufacturing, was regarded as a public enemy by the working-men, and was treated as such. Hargreaves, Arkwright, Cartwright, and others, drew upon them the displeasure of the mob. These operatives were of the opinion that every machine which could do the work of two men threw one of them out of employment. This was true; but their mistake was in not seeing that where one man was displaced in a certain specialty by the machine, it at once so enlarged the demand for raw material that two or more men were given employment for the one thrown out. Thus, the spinning-machine, followed by the power-loom, threw a great many spinners and weavers out of their employment at the spinning-wheel and the hand-loom; but it so increased the demand for cotton that thousands of men were given work in growing and handling it; there was a demand for additional seamen to transport it; for other men to care for it at the factories; for the additional artisans given employment in the construction of the new inventions, and for innumerable other necessary industries which grew from the increased supply; so that in place of one spinner or weaver thrown out of work, scores and perhaps hundreds of others were given labor under the new order of things. But the working-men did not take this enlarged view of the matter; and hence, when any machine was produced they proceeded to smash it.

The same thing occurred on several occasions when foreign artisans were brought into England. Mob after mob attacked the Flemish weavers who had located in Great Britain; many lives were lost, and great quantities of property were destroyed by the native spinners and weavers, with the insensate hope that it would improve their condition. In 1685, when the persecution of the Protestants was at its height in France, there were

not less than a half million of Frenchmen who left their native country, of whom it is estimated that not less than seventy thousand went to England. This was at the period when Louis XIV. revoked the Edict of Nantes —which, as every one knows, was issued after the massacre of St. Bartholomew, and was a guarantee of the toleration of the Protestants. These new-comers brought many improvements in the arts with them; but they had to encounter the hostility of the insular Anglo-Saxon-Norman population; so that, except that their lives were safer, they were but little better as to condition than before they left France.

The same hostility against mechanical improvement obtains in England to-day. The employers are largely at the service of the trade-unions; but while these organizations may not be harmful in most respects, there are others in which they have shown that men can be as brutal, as blind to the general interests, as they were two and three centuries ago. To the extent that they oppose improvements in machinery; to the extent that they resort to "ratting" to carry out their opposition, and yet again, to the extent that they do not hesitate to maim, and not unfrequently to even kill those who have become obnoxious, they are no improvement on their ignorant and savage ancestry.

Another inventor who was destined to undergo hardships without end, was Marie Jacquard, who was born in Lyons, France, in July, 1752, and who died in 1834, at Oullins. His parents were weavers and very poor, in consequence of which the son received substantially no education save such as he obtained at the loom, and a very few months in school. He was apprenticed to a book-binder when he was twelve years old; and later, in turn, to a cutler and type-founder. During the periods of his apprenticeship, he developed a fondness for

invention, and made several valuable improvements in the processes of the different trades with which he was connected. At the age of twenty, his father died, and he was called home to care for his mother. There were two looms left by his father, which he took charge of, and became a weaver. He did not succeed in his new vocation, for the reason that he gave so much time to studies of improvements in weaving that his business fell away, and he became bankrupt. He then became the assistant of a lime-burner, until 1793, when he joined the revolutionary party, and later, assisted in defending Lyons against the army in which he had at first enlisted. He enlisted in the army of the Rhine, and fought until his son, a youth of only fifteen, was killed by his side, and then he deserted. At first he found employment with a wealthy silk manufacturer, to whom he communicated some ideas which he possessed in regard to shortening the processes of pattern weaving. Up to this time the variety in the production of the various woven patterns, and in fact the patterns themselves, were the result of hand action, being accomplished by men and boys, whose condition was such that their life was much shortened. Jacquard was of the belief that all these manipulations might be done by mechanical processes. His employer, being struck with his suggestions, and being a man of a liberal nature, gave him a sum of money and set him at work to evolve his idea. In 1800, he produced a model of his automatical attachment for the weaving of figured goods; and met with success, receiving a medal for his invention at the National Exposition in 1801. He also invented a machine for the weaving of nets without the use of the shuttle, and for this was given a gold medal.

In 1804 he returned from Paris, where he had been handsomely treated, and employed by the government,

and became at once the target for the attacks of the mob. They thought that the looms, or attachments, which he had invented, would take the place of weavers, and thus reduce them to starvation. Great meetings were held, at which it was determined to destroy his looms which had been erected in Lyons; and they were only prevented from carrying out their designs by the interference of the military. Prevented from venting their spite on him or his property, they denounced him in unsparing terms, and proceeded to hang him in effigy. At another attempt, one of his looms was captured and broken in pieces; he was seized by the mob, who dragged him towards the river for the purpose of drowning him, which they were only prevented from doing by the interference of the soldiery. It was only when other cities had adopted the loom, and began to show signs of prosperity, that the people of Lyons were induced to alter their mind. They admitted the loom; and very soon found that in place of ruining their business, it had the effect to largely increase it. Jacquard lived quietly and humbly, and died without any fortune. Some of his relatives, a few years after his death, were so pressed by poverty, that they were obliged to sell the gold medal which had been given him by Louis XVIII. His improvement was of the very highest importance, and has been the means of placing his name in ineffaceable characters on the roll of honor of the Inventors.

CHAPTER XVII.

THE JACQUARD AND OTHER LOOMS.

IT should be stated that what is known as Jacquard's pattern-loom is not universally conceded to be his creation from the conception to the completion; but there are some who hold that he simply carried forward to a practical end a machine which had been suggested by another person. English writers assert that the first inventors of the pattern loom were Bouchon and Falcon; and that a noble and ingenious person, named Jacques de Vaucanson, had a good deal to do with it before it was taken up by Jacquard and brought to comparative perfection. In a report of the Paris Exposition of 1855, it is stated that there were nine models of the Jacquard loom on exhibition, showing the development of the machine. These models went to show that, in 1725, Bouchon employed a band of pierced paper pressed by a hand-bar against a row of horizontal wires, so as to push forward those which happened to lie opposite the blank spaces, and thus bring loops at the lower extremity of vertical wires in connection with a comb-like rack below. Three years later, Falcon substituted a chain of cards, and the cylinder in place of the band of paper used by Bouchon. In 1745, Vaucanson "suppressed altogether the cumbrous tail-cards of the draw loom, and made the loom completely self-acting, by placing the pierced paper or card upon the surface of a large,

pierced cylinder, which traveled backwards and forwards at each stroke, and revolved through a small angle by ratchet work. He also invented the rising and falling griffe, and thus brought the machine very nearly resembling the actual Jacquard." *

A description of the Jacquard invention cannot be made that will be readily understood by the reader unfamiliar with the processes of weaving, or the technicalities of this branch of industry. The following from the pen of one of the first mechanics of this country will come more nearly to having a general comprehension than any other which can be constructed. "The appendage to the loom which constitutes the Jacquard attachment is to elevate or depress the warp threads for the reception of the shuttle, the action being produced by cards with punched holes, which admit the passage of needles which govern the warp thread. The holes in a card represent warps to be raised for a certain passage of the shuttle, and the needles, dropping into the holes, govern the formation of the shed, so that the required threads of warp come to the surface. The next card governs the next motion of the warps; and so on, the required color being brought up, or kept as the case may be. For figured stuff, from the finest silk, to the most solid carpet, figured velvet and Wilton carpets, we are indebted to the genius of Jacquard, who made it possible to do by machinery what was before an expensive operation requiring skillful hands." †

The process of preparing the perforated patterns for the loom is no small task, especially in the larger works. For heavy materials, the cards must be of sheet iron. It is said that an elaborate damask design may require

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* *Report on the Paris Exhibition*. Rev. R. Willis.

† *Mechanical Progress*. Edward H. Knight.

as many as four thousand cards and four hundred needles. Some designs have required twenty thousand cards, and the labor of a single man for a year in preparing them. Several efforts have been made to reduce the expense and time involved in these preparations, among which that of a Frenchman named Bonelli, has attracted wide attention. In 1854, he began, and subsequently improved very greatly an electric loom, in which the cards of the Jacquard apparatus are superseded by an endless roll of paper covered with tin-foil. This is arranged by the making of the tin-foil non-conducting at points which would represent the perforations in the cards in the Jacquard attachment. By means of a galvanic battery connected with the tin-foil, metallic teeth are connected with a soft iron magnet, by which certain rods are moved so that the needles lift the warp the same as in the original machine. By other electric attachments, different sorts of weft and colors can be worked, as may be desired.

There are also some improvements made in this loom in this country, but nothing of an essential character.

A very curious invention is that of the stocking-loom for the manufacture of stockings, which was made by William Lee in about the year 1589. Of late, the knitting-machine has come into such general use that it has almost wholly supplanted the knitting by hand; and one more of the pleasant memories of childhood is about to be effaced. Who does not remember the old open fireplace, with its ruddy flames, and in the evening, the long shadows which stalked across the floor, and hid in the corners, flashed fitfully over the walls and across the ceiling, and within whose radiance sat the family; the men discussing the probable crops, the latest political gossip, or the newest sensation; the women with their knitting, their fingers flying; the grandmother looking

dreamily into the depths of the fire; the eyes of the younger bright as with the anticipation of some beneficent fact? There were the grandmother, with her faraway gaze; the mother, with her more practical face, mentally taking stock of supplies of butter and eggs and the possibilities of a rise in these commodities; the eldest daughter, robust, healthful, strong in feature, with luminous eyes full of anticipatory joyousness; and the youngsters, with their heads pillowed in the lap of their mother, sitting on low stools, asleep, perhaps, or studying possibilities in the shape of breaking a colt, or the future of the pair of steers which they were permitted to call their own. But who knows what a boy thinks; now of the zenith, then of the nadir; now of a star, and anon of the earth—thought darting hither and thither, everywhere—like the eccentric and sudden flights of the humming-bird?

It was in such scenes as these that the knitting-needles held their place. Each girl was taught, as she was the catechism, how to "set up" a stocking; how to "cast on" the stitches; how to "seam" in "one or in two;" how to "narrow," to "set" the heel, and to "bind it off," all in first-class shape. When the ladies exchanged calls, the knitting work was a regular attendant, and the rapidity of their tongues was only equalled by the swiftness of the busy fingers. "Come and bring your knitting!" was an invitation that meant, "Come and spend the afternoon with me!"

But, alas, a grimy man now sits in front of a machine all steely in glow, with hooks, and needles which ply back and forth incessantly, into whose maw go colored threads, and from whose alimentary duct there issues the stocking! No romance here! No back-log fire, with its glancing flames, its furtive shadows, and molten depths in which castles rear their turreted heads, and

long vistas of glorious expectation lead into the unfathomable depths!

The origin of knitting is not known. So far as can be ascertained, the first stockings known in England were a pair of silk ones that came from Spain. Hose were worn in England in early days, but they were not knitted, but made of pieces of cloth sewn together. In 1564, an English apprentice, who was in Mantua, saw in the windows of an Italian merchant a pair of knit worsted stockings, which he borrowed, and made a pair exactly like them, which are said to have been the first stockings of woolen yarn knit in England.* Queen Elizabeth seems to have been about the first lady in England who wore stockings, the first pair having been presented to her by Mrs. Montague. In her reign, knitting became a pervading industry, as well in private families as in shops in which knitted goods were a specialty.

Recognizing the value of knitted stockings over the clumsy cloth hose, invention at once contributed its aid to extend the benefits of the new discovery. The aid of machinery was invoked by the genius of invention, and the result was a revolution. The man who produced this revolution was named William Lee, who was born near Nottingham, about the year 1563. Concerning him there are many legends and romances extant, few or none of which are probably founded on truth, but all of which are interesting. That he was of a good family is conceded, and so are the statements that he graduated at St. John's College, and that he became curate of Calverton, a place not far from Nottingham. It was while curate at this place, in about 1589–90, that he invented the stocking-loom.

It is as to the motive which induced him to undertake

* Stowe.

this invention, concerning which there are extant so many romances. One of them is to the effect that he was in love with a country girl, who was always so occupied with her knitting that she would give him no hearing. From motives of revenge he was actuated in this instance; he wished to have a machine to make stockings so that the making of them by hand would be without profit; and thus deprive the cold-hearted young woman of her means of livelihood. Another romance is that he was deeply in love with a young country girl, and that he set himself at work to invent a machine which would lessen her labors with the needles. Still another is that he, being afflicted at seeing his wife so incessantly occupied with knitting—which she had to do in order to aid him in securing a living—sought some means of attaining the same end by machinery, which would at once relieve her, and procure for them a livelihood. There is doubt as to all these stories; there is an especial and well-grounded doubt in the incident of the story of the suffering wife, as nearly all the English authorities are unanimous in the conclusion that he was not married.

Curious as are all these romances, they are not more so than the invention taken in connection with all its surroundings. He was a clergyman; he had not the smallest notion of mechanics; and it is difficult to see what led him into the direction of thinking of inventing a knitting machine. Despite all the disadvantages of his situation, he commenced work, and in three years, had completed the stocking-frame. The only parallel of his case is furnished by Rev. Cartwright, the inventor of the power-loom.

One of the incidents which led to his determination to invent a knitting-machine, is thus related: It was an ancient tradition around Woodborough, his birthplace,

that Lee in youth was enamored by a mistress of the knitting craft who had become rich by the employment of young women at this highly-prized and lucrative industry. By studying fondly the dextrous movements of the lady's fingers, he became himself an adept, and had imagined a scheme of artificial fingers for knitting many loops at once. Whether this feminine accomplishment excited jealousy or detracted from his manly attractions is not said, but his suit was received with coldness, and he rejected with scorn. Revenge prompted him to realize the idea which love first inspired, and to give days and nights to the work. This ere long he brought to such perfection as that it has since remained without essential improvement, the most remarkable stride in modern invention. He thus taught his mistress that the love of a man of genius is not to be slighted with impunity.*

After his loom was completed, he worked it for some time at Nottingham; but the prevailing prejudice cropped up; he was taking the bread out of the mouths of the laboring men; and thereupon he removed his looms to London. He attempted, after reaching London, to secure a patent from Elizabeth. In time she consented to visit his works, which had been erected in Bunhill Fields, accompanied by Lord Hunsdon; but expressed herself after the visit, as pleased with the ingeniousness of the loom, although evidently disappointed that it did not knit silk in place of worsted hose. She finally refused the application for the patent, saying to Lord Hunsdon: "My Lord, I have too much love for my poor people who obtain their bread by the employment of knitting, to give my money to forward an invention that will tend to their ruin by depriving

* Dr. Ure. 1833.

them of employment, and thus make them beggars. Had Mr. Lee made a machine that would have made silk stockings, I should, I think, have been somewhat justified in granting him a patent for that monopoly, which would have affected only a small number of my subjects; but to enjoy the exclusive privilege of making stockings for the whole of my subjects is too important to be granted to any individual." * Lee thought there might be a suggestion in the remarks of the "virgin queen," and proceeded to construct a machine with which he wove silk stockings, a pair of which he sent to her majesty; who took the stockings, and again refused the application for a patent. His friend, Lord Hunsdon, died, and he was deserted by everybody. He was invited over to France by Henry IV., to establish his business in that country. Before he had gotten his business in shape, his patron fell under the knife of the fanatic Ravaillac; and Lee, losing all hope, fell sick, and died in Paris in 1610. Before his death he attempted to press his claims before the court at Paris; but being a foreigner, and not of the prevailing religion, he received no attention, dying, when he did die, in extreme poverty and distress.

Such was the fate of another inventor; his case another contribution to the martyrology of a profession the world owes more than to any other class.

It is a peculiarity of Lee's invention that it was in no particular the result of suggestions which had already been developed, or of initial efforts by other inventors. He gave birth to the conception; and his was the design. It is rarely that such is the fact with inventions in general; the invention is the fruitage of a plant which has been long in existence.

* Barlow.

Various improvements have been made from time to time in the loom invented by Lee. The Lee machine knitted the material in flat strips, so that in the making of a stocking, the strips were cut the proper length, and then seamed together at the edges. In 1816, Brunel constructed a circular knitting-machine, which was named the Tricoteur, and which produced the knitted product in the form of a tube; and it was so arranged that it could be adapted to any size, even that of the largest carpets. Brunel was for a time in the United States. He was born in Normandy, in 1769, and entered the French navy; but when the revolution came, as he was a royalist, he left the country, and came to this country. In 1799, he went to England, where he was engaged in extensive engineering works, and in developing certain other inventions, among which nail-making machinery, veneer-cutting, and shoe-making machines may be mentioned. He received a large gift from the English government: was knighted, and died at the age of eighty, in 1849.

It is said that there have been over three hundred improvements added to the Lee machine since its invention. Many of these have been by Englishmen, and some by Americans.

In the latter portion of the eighteenth century, the Lee machine was first brought to this country, and set up at Philadelphia, and Germantown, Pa., New York city, and several other places in the Eastern and Middle States. The first one who applied power to them is said to have been Timothy Baily, of Albany, in 1831. Several improvements have been made by Americans, one of which by Gist, is a circular frame in which eight feeders can be worked at once instead of one; and striped work of sixteen colors on a head four inches in diameter, making three hundred and fifty pounds of loops, or

a yard in length of web, in a minute.* The rapidity which is attained by some of these machines may be known from a statement that a person can by hand form one hundred loops a minute, while the Attenborough loom for the weaving of shirts, makes in the same time, nearly three hundred thousand loops.

At present, the knitting-machines are used for making many other articles than stockings, among which

LAMB KNITTING-MACHINES.

may be mentioned undershirts, drawers, comforters, scarfs, opera-hoods, talmas, nubias, gloves, mittens, mits, etc., etc.

One of the most remarkable of these knitting machines is one known as the Lamb knitter, from the name

* *Hosiery and Lace.* William Felkin

of its inventor. He is, as were Lee and Cartwright, a member of the clerical profession, and without any previous knowledge of mechanics. It is very simple, consisting of two straight rows of needles, and knits over twenty kinds of garments in addition to hosiery, gloves, and mittens of all sizes. The inventor, Rev. I. Lamb, is now in Michigan, engaged in trying to invent the paradox of a single-thread, lock-stitch sewing machine.

Lace-making belongs to the department occupied by the loom, although it was not until after the middle of the sixteenth century that lace began to be made by machinery. Before that time, it was all made by hand, and a great deal is still thus made at the present day. The manufacture of lace, in its origin is so remote in antiquity, that there is no authority from which it can be located with anything like exactness. Some writers are of the opinion that the lace mentioned in the Bible, and in other of the earlier writings, was merely some form of embroidery, or needle-work. About all that we do know, and even this we do not know with entire certainty, is that lace was first manufactured in either Italy or Flanders, as early as the fifteenth century. The earliest laces known are from Genoa, Venice and Milan; and that known as "Venice point" had an almost fabulous value. What is known as pillow lace is credited with being the invention of a woman named Barbar Uttman, who began its manufacture in 1561, at Annaberg, Saxony, although there are some authorities that assert that it was in existence in Flanders long before the date at which she is said to have invented it, and that her only connection with it was to introduce it into Germany.

During the sixteenth century, Flanders was the great centre of the manufacture of the finer kinds of lace; "the article produced was of great beauty; the old Flemish laces, the Brussels point, and Mechlin rivalled

the best of the Italian." It was not till 1666 that lace began to be made in France, in Alençon, by the famous Colbert, who imported some thirty women from Venice to form the nucleus of the new industry. It was at this point that was produced the celebrated point d'Alençon, or, as it was first named, point de France. The new industry grew with great rapidity, being valued at not less than one million, six hundred thousand dollars per annum, in less than half a century after its establishment. Spain at the same time produced a lace of a very high value; but the manufacture of it did not last for any great length of time. The making of hand lace came into England in the latter part of the fifteenth century.

The making of lace by hand is still a large and profitable industry in many parts of Europe, in England, France, Germany, and Belgium. The most noted made in England is the Honiton, which obtained its celebrity from the fact that Queen Victoria ordered her wedding dress of this material, at a cost of five thousand dollars; and in this respect, her example was followed by two of her daughters, and Alexandrina. Of the French laces, that which is most noted is the point d' Alençon. In the Exposition of 1867, there was exhibited a dress made of this material, at Bayeux, "consisting of two flounces and trimmings, the price of which was seventeen thousand dollars; and which required the labor of forty women for seven years to complete it." The Chantilly laces of France have a very excellent reputation. In one manufactory, in Auvergne, there are one hundred and thirty thousand women employed in the making of lace. Belgium ranks high in the quality of its laces; and there are one hundred and fifty thousand women employed in its manufacture. The most noted of the laces of Belgium are those known as Brussels. "The

thread used, which is made at Hal and Rebecq-Rognon, of flax grown in Brabant, is of extraordinary fineness. The finest quality is spun in dark, underground rooms, to avoid the dry air, which causes the thread to break, and to secure the best light, which is done by admitting a single beam and directing it on the work. It is the fineness of the thread, as well as the delicacy of the workmanship, which has given to the best Brussels lace such celebrity, and rendered it so costly. It is often sold at one thousand, two hundred dollars a pound, and has been quoted as high as two thousand, five hundred dollars." * Mechlin lace still has its favorites, although it is said that there is a decline in the demand for it. The celebrated Valenciennes, once the product of the Belgian workers, is now made in Flanders.

The first attempt to use machinery for the making of lace was in England, in the latter part of the eighteenth century. The loom of William Lee was one of the main agencies employed in the new method of lace-making; but there were other attachments. Not very much progress was made until about 1808, when a machine was produced by John Heathcoat, which answered his purpose for a time; which was pronounced by Lord Lyndhurst "the most extraordinary machine ever invented;" but which he soon threw aside, and in 1809, he had invented and completed another, upon which there has since been no substantial improvement. The new invention was called the bobbin-net machine, and it at once brought its inventor into prominence.

Like so many other inventors, he was of humble parentage, being the son of a small farmer, living in Leicestershire, where the son was born in 1784. He had just enough education at the school to enable him

* *Am. Cyclopædia.*

to read and write, and was apprenticed to a frame-smith. When he was only fifteen years of age, he expressed his conception of an invention by which lace could be made which would be as good as the lace then made by hand. He did make an improvement in the warp-frame; but while the result was that the product looked like lace, it was not lace, and therefore his "improvement" was abandoned. "Many ingenious Nottingham mechanics had, during a long session of years, been laboring at the problem of inventing a machine by which the mesh of threads should be twisted round each other on the formation of the net. Some of these men died in poverty, some were driven insane, and all alike failed in the object of their search. The old warp-machine held its ground." *

Heathcoat married when he attained his majority, and settled in Nottingham, where he occupied his mind with attempts to solve the problem of the lace-machine. He was poor, but so far as known, his wife had faith in him, and made no complaint when they were face to face, as they often were, with poverty. He had to give up a good deal of his time when he was earning wages to attend to his invention, and this made their income a most scanty one. It is related by Felkin, in his memoir, that "many years after, when all difficulties had been overcome, the conversation which occurred between the husband and wife one eventful Saturday evening was vividly remembered. 'Well, John,' said the anxious wife looking in her husband's face, 'will it work?' 'No, Anne,' was the sad answer, 'I have had to take it all to pieces again!' Though he could still speak hopefully and cheerfully, his poor wife could restrain her feelings no longer, but sat down and cried bitterly. She had,

* *Self-Help*. Smiles.

however, to wait only a few weeks longer; for success, long labored for and richly deserved, came at last; and a proud and happy man was John Heathcoat when he brought home the first narrow strip of bobbin-net made by his machine, and placed it in the hands of his wife."

That department of weaving which produces carpets is one of great interest, not only on account of the beauty of the fabrics but the great place it fills in modern industries. "Carpets," says Christopher Dresser, "like nations, have their place in history. The palace of the Pharaohs, the temples of Heliopolis, the mansions of Greece and Rome, the dwellings of Persia, China, India, and Morocco, all had their carpets, which therefore come to us from a venerable antiquity." * The same writer quotes from Plautus, who speaks of Sardinian carpets as being spread beneath "the ivory feet of purple-cushioned couches;" and also of the banquet of Ptolemy Philadelphus, at which there were two hundred golden lounges, among which were strewed purple carpets of the finest wool, with the carpet pattern on both sides; and handsomely-embroidered rugs "beautifully elaborated with figures," and thin Persian cloths covered the space where the guests walked, having the most accurate representations of animals embroidered on them.

Of the antiquity of carpets, there can be no doubt, as they are met everywhere in the annals of the past. They were not merely woven stuff; they were works of art, on which was embroidered an illimitable number of fanciful figures of all sorts.

So far as known, the earliest manufactories of carpets were in Persia and India, and as there is a similarity between the products of the two, it seems probable that they had a common origin. The Moors brought the

* *British Manufacturing Industries.*

first carpets into Europe, during their occupation of Spain, and from thence they spread into Italy, and a little later into Western Europe. The manufacture of carpets is said to have been introduced by France during the reign of Henry IV., and into England in the time of James I. Prior to their importation, the floors of rooms were covered with fragrant rushes.

At the outset, carpet-making was simply an imitation, an attempt to reproduce the beautiful products of the East. Even as late as 1750, in England, the Society of Arts gave a prize for the best imitation Turkey carpet. At the present time, with all our advances, our Turkish carpets are made as they are in Persia, and the well-known Axminster is simply another imitation of another form of Persian manufacture; it takes its name from the town, in Devonshire, England, in which it was formerly made.

The weaving of carpets in Europe was for many years done at the hand-loom. The Jacquard attachment simplified very much the weaving of patterns. Under this method of weaving, eight yards a day was considered all that could be done by a single person in weaving "two-ply ingrains." In 1839, an American, named E. B. Bigelow, of Boston, invented a power-loom, by which the productive capacity of a single loom was increased many fold, which was followed by a very material reduction in the price of carpeting. The value of this industry may be approximately estimated from the fact that England alone exports each year carpeting to the value of some fifty millions of dollars, of which more than one-half comes to this country; and this, despite the fact that there are many millions of yards of carpet made each year in the United States.

Calico-printing is also one of the oldest of the processes of weaving known to the ancients, although, of

course, not to the extent to which it is known at the present day. Two thousand years ago, the art of printing cloth in colors was known in India, and as were also "one or more styles of calico-printing, including chintz patterns and the resist process." * Calico, as everybody probably knows, is cotton cloth, of various colored patterns, which, in place of being woven in, as is done in carpets, shawls, and the like, are painted, or dyed in by machinery. As calico is no more than white woven cotton, the only facts of interest connected with it in this chapter, relate to the methods by which the various patterns are produced.

The process which at first prevailed for the coloring of this fabric, and which, indeed, is yet not out of use, is known as block-printing. In this method, the pattern which it is designed to give to the cloth is drawn on a wooden block, on which the pattern is cut in relief; or in some instances the pattern is formed by the insertion of small slips of copper wire, the interstices being filled with felt. At each corner of the block, there are pin points fixed which enable the printer to place it in its proper position on the cloth. The white cloth is then laid on a firm surface, and the wooden block, having been dipped in the proper coloring matter, is pressed on the cloth. This is a very brief outline of the methods of block-printing; the processes are much more complex in detail than here described; but the principle of the art can be understood from this outline description. In 1834, a Frenchman, named Perrot of Rouen, invented a machine for doing this block process; and which is a vast improvement over the tedious hand application. It was improved in 1844, to an extent that enabled it to produce the most desirable effects, and perform the work

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* Knight.

of fifty men, requiring only two for its manipulation. It is named the perrotine, after its inventor, and is not very much used outside of France.

The other form of pattern-printing is also a mechanical one, being in principle very much like ordinary printing, except that the design is cut on a cylinder. This process was introduced in London more than a century ago, or in the year 1770. There are several claimants to the invention of cylinder printing of calicoes, among whom is a German, named Oberkampf, at Jouy, in France, and a Scotchman, named Hill, who brought out his machine in 1785. In this process, there is a copper cylinder of some thirty inches in length, and from four inches to one foot in diameter. The pattern is impressed on it from a cylindrical die. The required color is spread on the rollers, and as they revolve, they impart the color and the pattern to the calico, as it passes beneath them. One of these machines can do the work of two hundred men; and do it much more accurately.

It may not be generally known that the influential Peel family of England, the greatest of whose members became prime minister, owe their rise from obscurity to their connection with, and their improvement in calico-printing. In about 1750, there lived a Robert Peel, with a large family, in a place named Blackburn. In intervals of farm-work he employed himself in making calico. He was of very humble circumstances; but is claimed to have been ingenious, and that while at work on calicoes he gave much attention to designs of improvements; and it is asserted by English writers that he was the inventor of rolling-printing. It is also asserted that the "process of calico-printing by what is called the mule-machine—that is, by means of a wooden cylinder in relief, with an engraved copper cylinder—was

afterwards brought to perfection by one of his sons."* His son, who was afterwards knighted, and the father of the prime minister, began life with all the energy of his father, all his determination to succeed, and with but little capital. In company with two other men, he managed to secure about two thousand five hundred dollars, and with this amount began in a small way, in calico-printing, to which in 1870, he added cotton-spinning. He married the daughter of one of his partners, a humble, modest girl, who made him an excellent wife, and a most valued assistant in his business correspondence; for it is the fact that Peel knew a good deal more about calico-printing than he did of the pot-hooks and hangers connected with hand-writing. The main event in his business career was his bringing before the public what is known as the "resist" process in calico-printing. He bought the secret of a commercial traveler for a small sum, but the results of the process were so marked that they speedily placed his house at the head of all the printing-houses in Great Britain. The resist process is one in which a paste, or a "resist" is used on such parts of the cloth as are desired to remain white.

His son, the prime minister, was a great man. It was he who reörganized the constables of Great Britain, and made of them policemen, such as they are now in England; and also in this country. It is for this reason that policemen are often referred to as "Bobbies," or "Peelers," Sir Robert Peel, the first, was given a baronetcy in the year 1800.

It is almost in the nature of surplusage to say anything as to the influence which has been exerted by the invention of machines for spinning and weaving. To-day, the products of the power-looms and spinners, and

*_Self-Help._ Smiles.

the various improvements which invention has given to the world, amount to not less than two billions of dollars per annum! To this most extraordinary extent has invention increased the value of the world's products in textile fabrics, but at the same time, it has immeasurably added to the comforts and the luxuries of living. Carpets are now within the reach of every household; hosiery, infinite in pattern and supply, can be had by all; lacé, which once was only within the command of the wealthy, can now be worn by the humblest. There is almost no limit to the benefits which have accrued to the world since spinning and weaving have reached their modern state of development.

Fancy the difference between the world as it is and as it was during the days of Queen Elizabeth! Then, titled women wore cloth stockings, the common women none at all. Then the floors were covered with rushes; the Axminster, Brussels, the Wilton were undreamed of. There were no curtains to the windows; the cheap prints were unknown; shawls were luxuries imported at a heavy expense from the Orient; the comfortable wraps, the infinite variety of goods in use to-day were unknown. The women wore the coarse products of their hand-looms; the men were often clad in sheepskin jackets, like the savages of the colder regions at the present time.

The poorest woman to-aay can afford to dress in some pretty stuff; and there are few but can afford to be clad always comfortably, and frequently in that which is becoming and durable.

What has been the average of benefit to the world from the improvements referred to, must be considerably lowered by the disastrous effects which have resulted to operatives by the establishment of factories. That the comfort of the human race has been vastly

increased by the machines invented for the handling of textile fabrics cannot be doubted; but the factory system has been fruitful of immeasurable evil to certain classes, more especially to the operatives. It may be said that it is the case that the happiness of the many invariably impinges with disastrous effort upon the rights of the few, and that in the factories of the world, while there is suffering inflicted on the minimum the maximum is greatly benefited. Possibly this is the only conclusion which can be reached that may be regarded with toleration; but even this does not reconcile the philanthropist to the condition in which so many operatives of the cotton and woolen factories are to be found. It may be said in extenuation of these results, that even as they are now, these operatives are better off than the same class of working-men and women were a couple or more centuries ago, before the introduction of automatic machinery; and that, while they are no worse, the average of the remainder of the race, in the matter of comfort and happiness, has largely advanced. In other words, such misery as appertains to these operatives is no greater than it would have been had there been none of these inventions; in fact, there is even less wretchedness than there was among them—as can easily be ascertained by comparing their condition now with that of their class before machinery came into use; and that it seems much greater by comparison with the comforts, luxuries, and other benefits which these mechanical appliances have given to the world.

But this phase of the results of invention forms no essential portion of the scope of this work. That the civilization of the race has been advanced by what invention has done for the production of textile fabrics cannot be doubted; that while the benefit to the whole cannot be doubted, it is equally true that this

benefit has not been equally distributed; that some get much more than others. The remedy for this inequality in the distribution of the results of labor is one of the most profound and difficult problems of modern times. Its nature and application are being agitated and discussed in all parts of the civilized world. Whether a solution of the problem does exist, and if so, can be found, is something which is as yet hidden in the profoundest depths of the future.

CHAPTER XVIII.

WOOD-WORKING MACHINERY, ETC.

PROBABLY the very first wood-saw was made of the backbone of a fish; and with equal probability, this saw was the first thing or implement invented for the working of wood. It may be that a sharp flint was in use before it for the hollowing out of logs for the construction of canoes; but the saw, in some form or another, must have been the very earliest of inventions. A serrated flint would make a fair kind of a saw, and this kind of an implement might be found in a natural state, in a flint quarry, and its use would almost at once suggest itself.

By-the-way, does the popular reader know what a wood-saw is? That is, not a saw when he sees it; but the principles of its construction? In modern use, there are two kinds of saws; the "cross-cut" and the "rip-saw." The former is so named for the reason that it is used for sawing across the grain of a piece of wood, and the other, or "rip," because it is used in cutting wood in the direction of the grain. In sawing a log in two, that is, across the grain, the cross-cut is used; but in sawing lengthwise, the rip is brought into play. In the cross-saw, the teeth are flat on the outer surface, and beveled down to a sharp point on the inside. Then the teeth are "set;" that is, every alternate tooth is bent a little outward, so that, in looking along the lower

surface of a saw, one sees, as it were, a groove with the sharp-pointed teeth on each side. Now, when this saw is laid on the wood, across the grain, the wood is cut by two rows of teeth, which are apart a very small fraction of an inch. A tooth cuts a fiber of the wood, and the tooth following on the opposite side, cuts the same fiber at a trifling distance from where it was cut by the other; and this little piece is dragged out in the form of sawdust, although it is really a small section of the fiber cut out; and its length is equal to the width of the cut made by the passage of the saw.

Now, if one were to take the same machine, and undertake to cut a piece of wood lengthwise, there would be no progress. It is readily to be seen that teeth thus arranged would not sever the grain or fibers of the wood, and hence there would be nothing taken out. The rip-saw is constructed on entirely different principles. It is precisely the same as if a series of small chisels were set one in front of the other, in such a manner that they could be pushed against a piece of wood, each one following the other, and cutting as it passes a small width of the wood. A rip-saw is simply a set of such chisels, each chisel being the size of a tooth, chiseling out a small fragment of the wood as it is driven through the article to be sawed. On looking at an ordinary hand-saw one would scarcely be likely to imagine that such principles are involved in its construction.

The earliest saws known were of bronze; and were regarded with such reverence that in some of the ancient nations, its inventor was deified. Perdix, or Talus, was the name by which the inventor was worshipped among the Greeks; and his is the only well-authenticated case in which the patent inventor has attained such high distinction. It is but justice to the inventor to say that

the lack of cases in which he has been apotheosized is owing, not to the fact that he has not deserved it, but to the failure of the world to appreciate his value.

The saw, the primitive instrument in the kit of the carpenter, was at first made with one handle, and then with two, a man standing at each end, and alternately pulling the instrument across the wood to be severed.

TOP AND BOTTOM SAWYER.

When it was necessary to cut a piece of timber, or a log lengthwise, then the wood was raised high enough to permit one of the sawyers to stand underneath, the other standing on the body of the wood being divided. From the fact that one hears, now and then, of a person being a "top-sawyer;" meaning thereby that he is superior in some pursuit or profession, it is to be inferred that

the working-man who stood on the top was regarded as occupying the most honorable position.

Many people not yet old will have no difficulty in remembering the use of the saw in this manner. As a matter of fact, improvements in the methods of sawing timber, logs and the like, have only come into prominent and general use within the last generation. There are statements to the effect that saw-mills driven by water were in use in Augsburg, Germany, in the year 1337; and that in the fifteenth and sixteenth centuries there were mills in use—in Breslau, 1427; Holstein, 1545; Lyons, 1555; Ratisbon, 1575; and in Norway in 1530. *

The first known saw-mill was erected in Holland, in 1596, and in Sweden about the year 1653; and although no account is given of the motor used, it was probably that generated by the windmill.

England came last in the list, the first mill of which there is any record being erected in 1663, by a Hollander, in the vicinity of London. This preliminary effort shared the fate of many of its initial predecessors and successors; it was regarded as taking the bread out of the mouth of the top and bottom, as well as the other sawyers, and was thereupon smashed without the slightest compunction by the angry mob. More than a hundred years after this, in 1768, a saw-mill driven by wind, was erected by an Englishman named Stansfield; but even he was in advance, and his mill went down before the mob. However, the government came to his aid, and he erected other saw-mills driven by wind in various parts of the country, which the mob graciously permitted, for some reason which does not appear, to escape destruction. In all these mills only the straight saw was known, the circular saw not being known till about

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* *Kunst und Handswerks-Geschicte der Stadt Augsburg.* Stetten.

the beginning of the seventeenth century, in Holland; but it was not introduced into England till near the close of the eighteenth century, at which time there is a record of a patent applied for by Samuel Miller, of Southampton, and in which a specification states that the implement is of a circular figure. He also claimed a method of bringing the timber up to the saw, the latter remaining stationary so far as a motion toward the wood is concerned. The first definite information as to a marked improvement in sawing was in 1805, when an Englishman, named Brulen, took out some patents for improvements in processes; and in which the circular saw appears, the whole of his processes being regarded as most wonderful at the time they were introduced to the public.

Saw-mills were in use in this country before they were in England, being introduced by the Dutch, who were at least a century in advance of the English in the use of that machine. In 1634, one was built on the Piscataqua river; and in 1636, several were erected by the Dutch, one of which was put up on what is now known as Governor's Island. In the improvement of the machinery of this class of mills, the Americans have taken a marked lead. In 1824, Robert Eastman, of Maine, patented a very ingenious machine by which planks were cut off a log from the circumference to the centre, instead of directly through the log, as is the usual method; it being claimed that planks thus cut possessed better qualities than if cut in the ordinary way. From 1810 to 1835, this branch of engineering remained almost stationary in England. "Even America, with little or no iron and less general resources, made far greater progress than ourselves, a number of patents being taken out for inventions and improvements in curvilinear sawing for ships' timbers,

mitre-cutting saws, barrel saws, etc., of which little or nothing was known in this country." *

It was not until about 1827, in England, that planing-mills came into use, being made from the patents of Malcom Muir, of Edinburgh. There had been various attempts before this time to introduce machines for planing, among which may be mentioned the invention of Mr. Bramah, in 1802, an Englishman, in which there was an upright spindle, on the lower portion of which there was a horizontal wheel to which there were fastened twenty-eight gouges. As the spindle revolved, the gouges cut the surface of the wood; these were followed by a plane, also fastened to the revolving wheel, which smoothed the rough cuts left by the gouges. This circular cutter has been improved by T. E. Daniels, of Worcester, Massachusetts, who substituted two cutters for the twenty-eight gouges; and in this shape it is still used, more especially in some departments of cabinet work. But the greatest improvement in the planing machine was made by William Woodworth, of New York, in 1828, in which there are cylindrical cutters such as are now seen in every modern planing apparatus. The cutters are attached to a horizontal shaft which revolves with great velocity, while the board to be planed is carried along under the cutters by rollers, which also clamp the board and hold it in place. There have been minor improvements added to the Woodworth planer; but it is yet to be superseded by something more rapid and efficient.

The invention of the saw-mill, using either reciprocating or circular saws; and the introduction of the planing mill were to the working of wood what the mule-spinner, and the power-loom were to weaving. They at

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* M. Powis Bale.

once increased the capacity of the sawing and planing industries more than a thousand-fold. Fancy the time and manual labor involved in cutting a log into boards when it had to be done by an upright saw worked by two men! Again, fancy the labor of planing an ordinary board, as it is often done yet, when a man had to go over its surface once with a "jack-plane," then with a "smoother," and lastly with a "jointer!" Now such a board is planed by machinery in less time than it takes the ordinary carpenter to make half a dozen preliminary strokes with the first of his three planes.

In the construction of planing-machines, the United States have led all the other nations. The Whitney machine, that by Fay, and others, have always attracted attention when exhibited abroad; and are in use in other countries as well as in that of their invention.

Processes of sawing have undergone numberless modifications. One of these is in the use of the band-saw, which is simply a thin, very flexible steel belt, revolving on pulleys, and having the teeth cut on one edge. These are used for innumerable purposes; in some instances for the sawing of logs into boards; in others for the finest of scroll-work, and the cutting of irregular forms, such as the varying timbers of ships. So far as is known, the invention of these is due to a Frenchman named Touroude, who patented the band-saw, in 1815. In 1845, the band-saw was again patented by another Frenchman named Thouard. But it was not till the International Exposition of 1855 that this class of saws received much attention, at which time Perin, a Frenchman, exhibited one which contained all the elements of those now in use. The English claim that the saw was invented by an Englishman named William Newberry, in 1808; but it is certain that if such were the case, it was not in use in England, except, till after

the year 1856, it was operated under French patents. In fact, the machines at first in use in England were some which were purchased from the French in 1856, and used in the government arsenal at Woolwich.

BAND-SAW.

In 1878, at the Paris International Exposition, the most complete band-saw machine was that exhibited by

Fay, of Cincinnati. Rogers, of Norwich, Connecticut, also exhibited one which attracted much attention. Even English authorities were constrained to admit the superiority of the American machines. "For general purposes, perhaps the most complete machine in the Exposition was that shown by Fay, of Cincinnati;" and then, in giving a detailed description of these machines, and their elaboration of the minutest details, it is said: "Recording these small matters may appear to be trivial; but, owing to the keen competition of the day, anything, be it ever so small, that either saves labor or adds to the productive capacity of a machine, all practical men will admit is of importance. And here we may add it is our opinion that much of the present success of American competition is due to the attention paid to the smallest details in their machine construction, which either increases the range of the work performed, improves the quality, or lessens the cost of production, which saving in a day may be infinitesimal, but when multiplied by days and years, amounts to a gigantic total. In point of fact, in comparing English and American machines for performing the same class of work, many American machines are carried further than our own." *

The scroll, or jigger-saw, is believed to be an American invention. Wells of Pennsylvania, Talpey of New York, Beach, the Fays, and the Rogers, are among those who have invented this machine, or brought it to its present state of perfection. Despite the poverty of the American exhibit at Paris, in 1878, about the only scroll saws to be seen were those in the collections of the American department. The value of this ingenious invention is an extended one; it may be driven by power,

* M. Powis Bale.

or by a treadle worked by the foot. It is of use in a thousand directions in the cutting of varying lines, and is an article which will afford unlimited amusement in a household for the cutting of wood into all kinds of fanciful shapes.

When the tree has been felled in the forests, dragged to the mill in the shape of a log, has been sawed into boards or timber, then has been taken to the mill and planed, it has but just commenced its journey; the gauntlet of machines which it has to run is yet mainly in front of it. If its destiny be for a moulding, it is sawed to the proper dimensions, and then is run through a machine whose teeth of steel eat away its projecting surfaces, and almost in an instant, it is an ogee, or some other form, designed for the cornice of a wooden building—the slender mould which is to be gilded and support the pictures upon the wall—or to become a portion of the massive finish of an interior doorway, or the slender "quarter-round" which holds the canvas in place in its frame.

Or it may be that the newly-cut board is intended for flooring; in this case it runs through a machine which grooves it on one edge, and "tongues" it on the other. Or it may be a heavier piece, intended to form the solid frame of some machine, in which case a mass of iron, chisels, and other appliances seize upon it, and in a moment the mortises are dug out, and the tenons formed, to construct which the patient carpenter would have to saw, and chisel for a time vastly longer than required by the untiring and unconscious machine which, aided by steam or water-power, has to perform the same work. The mortising-machine is claimed by English writers to be the invention of Sir Samuel Bentham, in 1798. The first use of the machine in England was in 1807, when Brunel, in connection with Henry Maudslay,

constructed several for the use of the government. In principle, the mortising-machine is precisely that of performing the same operation by hand. A chisel—in some cases—the width of the mortise, is driven into the wood by the force of an appliance driven by water or steam, instead of by a mallet as when done by hand. As the chisel is withdrawn the wood is moved a trifle forward, and so on till the mortise is completed. The difference between the machine and the hand is that the former never tires; that the machine drives the chisel vastly more rapidly; and that by increasing the number of chisels, as many mortises can be cut at once as may be desired. Thus, in making the mortises in window-sash, the hand-worker can make but one mortise at a time, while with the machine, a half dozen can be made at once as easily as one. Since the invention of this machine there have been various improvements on it, in which Americans have played a principal part. In 1826, A. Branch, of New York, brought out a mortising-augur for the making of square holes. An important improvement was made by H. B. Smith, of Lowell, Massachusetts, in 1853; and Thomas Guild, also an American, made some valuable additions, among which was one for graduating the stroke of the chisel by means of a treadle; and the next year, Adancourt, an American, invented an improvement by which by the use of an expanding boring-bit, a conical hole could be made and the chips removed at the surface.

In 1877, William W. Green, of Chicago, obtained a patent for a novel mortising-machine, thus described: It consists of a revolving endless chain-saw, formed of pivoted sections or links with cutting teeth, to which the proper tension is imparted by a grooved tension-bar, the wood being fed and guided to the mortising-saw by a movable treadle-acted table or bench. It is known as

the Chain-Saw Mortiser; is very simple, noiseless, and in excellent repute among those who use it.

Bale, in some remarks on these machines, says that, on the whole, the "American mortising-machine may be said to be in advance of ours." The same sort of testimony is applicable to the tenoning-machines, which have for their purpose the shaping of the tenon which is to fit into the mortise. At the Paris Exposition in 1878,

CHAIN-SAW MORTISER.

the Fay exhibit, and that of Rogers, were far in advance of all others; and the same is true of the machines which were exhibited in the American department, for the purpose of doing what is known as dove-tailed work.

Machinery for the cutting of veneers has been in use for a long time, it being claimed that Bentham patented some for veneer-cutting as far back as in 1793. In 1805, Brunel took out a patent for veneer-cutting by the use of a circular saw; and since that period, there have been many improvements. In 1847, a German, named Belter, living in the United States, patented some valuable

improvements; he was soon after followed by some others, the invention of a Mr. Meadows; and some few years later, L. R. Hawes still further improved the machine, in which he had the knife remain stationary, and which cuts off the veneer somewhat as a chopper slices a piece of cheese. There is also in use a machine in this country in which wood-hangings are prepared, to be used for curtains, for decorations of walls, and similar purposes.

Perhaps the most remarkable machine in use in the working of wood is the one that constructs irregular forms, such as spokes for wagon-wheels, axe-handles, gun-stocks, and similar articles. In the United States it is claimed, and universally believed, that the invention of this machine is due to Thomas Blanchard, who was born in Sutton, Massachusetts, in June, 1788. The English authorities say that the principle of most of the machines now in use for the turning and dressing of irregular shapes is contained in Boyd's patent of 1822; then they say that an Englishman, named Jordan, in 1845, introduced a machine for the copying and carving of irregular forms; and then the same authorities assert that about 1855, an Englishman, named Hughes, patented a machine for dressing spokes, and other irregular forms; finally they state that some of the greatest improvements "in automatic lathes for turning irregular shapes were made and patented by Mr. Blanchard, an American, many years back, whose machine was undoubtedly one of the most remarkable inventions of the day." This is apparently a fair statement, but it is nevertheless a very disingenuous one, as the invention of Blanchard was made and patented before the very earliest invention of the kind accredited to an Englishman, namely, Boyd's' patent of 1822. Blanchard patented his machine for the turning of irregular forms as early as 1815, at least seven years before anything of the

kind was known in England. This is the "many years back" alluded to by Bale; his intention evidently being to convey the idea by the expression that Blanchard was long after Boyd, Hughes, and Jordan.

Blanchard was a man who was quite as remarkable as his machine. He was a mechanic, whose earliest occupation was that of making tacks by hand, a process so very slow, that he conceived the idea that the same results could be reached by the aid of machinery. He gave six years to the study of his conception, and at the age of twenty-four, he completed a machine so admirable, that by merely placing the iron in the hopper, and applying the power, it would turn out five hundred finished tacks each minute, and furnish a much better article than that made by hand. His next invention was a self-acting lathe that would turn out a gun-barrel; and this was followed by one for the turning of gun-stocks, which was a success, which was at once adopted, and with but little change has held its place to the present day. He interested himself in other things; he constructed a steam-boat which would ascend rapids of considerable force; and invented a steam-wagon before any railroad had ever been built. In all, during his active career, he obtained twenty-five patents for inventions, the last of which was a process for the bending of heavy timbers to any desired shape. He was engaged in applying this patent to a practical use when he died, in Boston, in 1864.

The machine on which his fame rests in this country, is for the turning of gun-stocks, and other irregular forms. There have been some improvements on his invention, but the principle is substantially the same as when the machine was first introduced. It is used for the turning of ax-handles and the spokes of carriage-wheels. At the Paris Exposition of 1878, there was

exhibited an American machine by Mr. Hosler, in which the spokes are driven into the hub by the blows of a mallet driven by steam-power, and which is so regulated that they could be given hard or light, or fast or slow, as might be desired. There is still another by Corr, an American, which not only drove the spokes into the hub, but which automatically cut off the spoke the proper length, and made the tenon on the end for insertion into the felloe.

The making of barrels by machinery has within late years become a very important branch of industry; and in this work, the inventors of the United States have been active and have secured their due share of credit. At the present time, more barrels are manufactured in this country than in any other, and all the work is done with machines of American invention, and American manufacture.

There are innumerable other machines for the working of wood which cannot be taken up in detail. There is a machine for using sand-paper in the finishing of wood surfaces; there are automatic, self-acting machines for the turning of broom-handles, and similar round objects. Machines are used for the sawing of the curved timbers of ships; for making boxes out of the solid block; for cutting down trees; for carving in some of its departments; for the pulling up of stumps; for the making of the splints of matches; for innumerable uses in the turning of wood for the making of furniture; and there are still scores—hundreds, perhaps—which have not even been alluded to in this article.

There is no country in the world where there is as much working of wood as in the United States. The value of the sawed and planed lumber alone is nearly or quite three hundred million dollars per annum. We export annually of wood and its manufactures from twenty

to thirty million dollars worth. It would need a large volume to describe all the uses to which this wood is put; and in view of this enormous consumption, a very serious question arises as to whence is to come the supply of the raw material at no very distant date in the future? The question is one of transcendent importance, but it cannot well be discussed in this volume.

Before closing the subject of the working of wood, there are two machines which should be mentioned, and which are not generally alluded to in works treating of wood-working machinery. They are of universal use; they have merits which entitle them to a conspicuous place among implements of utility, among those which have played a most important part in the developments of civilization. They are the pocket or "jack" knife, and the ax.

The former is at once an implement and a sentiment. As a machine, its uses are innumerable, its value inestimable. The farmer could no more get along without his jack-knife than he could without his plow, or animals for draught. It is in demand a score of times every day; it labors when its owner labors, and rests only when he sleeps. If the whiffletree band becomes loose it is the jack-knife which furnishes the wedge and the remedy. It provides a plug for the leaky wash-tub or the barrel of vinegar; it whittles the kindling for the morning's fire; and shapes the shingle into a spoon with which the boy applies ashes to the young and growing corn. It supplies a substitute for the missing bung; it reduces the dimensions of the new helve for the ax, and supplies the wedges with which it is held in place. It furnishes the missing pegs for the warping-bars, the sticks for the complaining swifts; hollows the boat, and slices the finger of the boy as he labors to secure a craft for the goose-pond or the

neighboring creek; it trims the slender sticks for the kite, notches the points of intersection, and hollows the ends of the sticks for the reception of the exterior cord. It cuts the young hemlock, or the branch of hickory, which is destined for the bow, and prepares the arrows with their notched end to fit the string. It carves on the gray surface of the beech grotesque faces, intertwined initials, and impossible monsters; it makes huge, yawning chasms in the pine of the school-desk, gouges holes through the seats, slices slivers from the slate-frame, and decorates the adjacent fences with notches, hollows, and all species of figures in bas and alto relief.

Two men lean over a fence, each has in his hand the faithful jack-knife; they cut into the wood; they pare off the little projections; and the while, they talk. National politics are argued, the latest gossip is overhauled, and trades of horse for horse, or horse for cow, with so much "boot," are accomplished as the industrious knife goes on with its unintermitting work. Two men sitting on casks, in front of the "store" at the cross-roads, each with bowed head, each with a pine shingle in one hand and jack-knife in the other, represent the sociability, the business conventions, the political mass-meeting of many a district. As the keen knife pushes its way through the yielding pine, commendation or the reverse is extended to the congressional representative, the needs of the old school-house are discussed, and the leakage of the church steeple is passed on, and the remedy provided.

As a sentiment, the jack-knife has an important place. It is to the Yankee inventor what the caduceus is to Mercury, the sceptre to royalty, or the tricolor to France; it is an emblem, a representative, a trade-mark. With it he has finished many a dream of new methods, processes and improvements; it has sympathized with

his thoughts as he overran the necessities and the possibilities of a situation—he pondering the while, it with keen and noiseless edge, shaving the shingle away to nothingness. It is his sympathizer, his companion, his friend; the sharer of his designs, the partner of his labors, and participant of his triumphs. With its aid he has fashioned into shape many a crude idea, and given form to what was before intangible. If the world owes much to the Yankee inventor, it is none the less indebted to his inseparable coadjutor, the jack-knife.

It might also be asked what the world would be without the ax? Where would be the civilization of this continent had it not been for this implement? Its ancestors came into being not long after man first saw the light of existence. Like them, it was crude, awkward, unfinished at the beginning; but has grown with the races until now, when its polished, steel-bitted blade is as bright, as enduring, as valuable as the best of them.

If one were asked to give an opinion to-day as to the most valuable of the machines for the working of wood, he would not be very far out of the way if he should give the place of honor to the gleaming ax. Glance, in imagination, over this continent as it was three centuries ago. Everywhere there would be an endless wilderness of vegetation, the spear-like poplar, the arrowy pine, the sturdy spread of the oak, the white trunks of the birches, the grand elms with their sweeping outlines, the fiery red of the sumach, the fragile and bending willows, and scores of other forms of every shade of green and every conceivable outline. All this area has to be cleared for the occupancy of man. Room must be made for tillage, the hill-sides must be bared for the sheep, and there must be place for the meadows for the cattle. There must be houses for the occupants, churches for the people, school-houses for the young,

prisons for the criminals, and courts for the location of justice and its assistants.

It is now that the ax comes forward and assumes this mighty labor. Day by day, year by year, and century by century, the music of its blows has rung out through the woodlands as it has cleared the way for the coming millions. The crash of the falling walls of the forest fortresses has rung incessantly, passing from ocean to ocean, from lakes to gulf, until now, when a continent is cleared of obstacles to the march of a great nation.

Nor is this all. It has accompanied the pioneer in his march into the wilderness. It has hewn the circle where a home was to be founded, and the beginning of generations established. It has squared the logs which were to form the walls of the home. It jointed them; it cut the materials for the chimney; it furnished the back-log and the fuel for the fire; it fashioned the first rude cot on which little children slept; dug the cradle from the trunk of a tree, and in which slept as soundly as if pillowed on down, and rocked in mahogany, infants that grew to be stalwart men and women, full of energy, free from taint of crime, fresh as the balsamic odors of the forests which environed them.

Who that ever has swung a keen and well-balanced ax against the base of a lofty tree, when the snow and the air were crisp, when the wintry sun looked on low down on the horizon, has ever felt a thrill like that which at this time rushed through his veins like a torrent, when every inhalation was intoxication and every blow taxed the strength as little as the swinging of a bunch of thistle-down? There is almost ecstacy in the very remembrance of these glorious days, when the air was champagne, when every nerve vibrated with an exquisite pleasure; when the soul swelled with all

the pride of a victor, as the great tree, shivering at its coming fate, tottered feebly for a moment, and then went thundering to the earth. How the crash of the fall was taken up by the forests! How the trees told it to the other trees, in tones which grew fainter, as if they were overcome by the disaster, and felt a premonition of their own fate!

The ancients worshipped the saw. The moderns have far more reason to extend the honors of canonization to the ax. It is the greatest of all that have assisted in the development of the destiny of man, especially on the western continent. When its steel edges have worn away; when its head is battered and indented from long years of service; when its bitt is notched, and broken, it should be given an honorable place among the Lares and Penates of the household.

CHAPTER XIX.

ENGRAVING ON WOOD, METALS, ETC.

IN regard to the origin of engravings, there is rather more obscurity than there is in reference to that of many other arts which have come down to us through the centuries. For a long time it was supposed that the first authenticated engraving of which we have any knowledge was one of St. Christopher, which is a very famous one among those who take an interest in such enquiries, and which bears date of 1423. It represents the saint fording a river with the infant Christ on his shoulders; and was found in the middle of the eighteenth century, fastened to the inside of the cover of a MS. in a convent in Suabia. But it is claimed that at least two earlier discoveries have been made, one of which, found by Baron de Reiffenberg, is ascribed to the year 1418. In the case of the other, two plates found in an ancient manuscript, there is reason for concluding that there was a knowledge of engraving possessed anterior to the year 1306.*

The Germans were for a long time of the opinion that the art of engraving on copper was the invention of Martin Schongauer, sometime about the year 1460; but this claim was set aside by finding a proof of the Peace of Florence, executed by Maso Finiguerra, dated 1452.

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* *Gazette des Beaux-arts.* 1869. Henri Delaborde.

Later investigations snow that several pieces were in existence before the date claimed as the one when Schongauer gave his first essay to the public.

SPECIMEN OF ENGRAVING IN FIFTEENTH CENTURY.
Reduced fac-simile.

That the ancients knew of engraving, so far as the art relates to the cutting of figures, cannot be doubted; for there are several places in the Scriptures in which engraving on metallic plates is mentioned. What the ancients did not know was the art of transferring the engraving to paper in the sense in which it is done in modern days. As was seen in the article on printing, the Chinese long before the period of Gutenberg, were in the habit of cutting letters on wooden blocks, and then printing from them; and this is, in all essential respects, engraving. But engraving is now defined as "the art of producing designs, either by incision, or corrosion, on the smooth surface of a wooden block, metallic plate or other substance, for the purpose of transferring them to paper. It is in this sense that

engraving is comparatively a modern invention, which began to be practiced a little in the fourteenth century, and considerably in the succeeding one.

Between 1430 and 1450, there was issued what is supposed the first of illustrated books, in the shape of what is known as the *Biblia Pauperum*, a small work of some forty pages, each of which was illustrated with a wood-cut, and contained in addition a text of scripture. The book was so named for the reason that it was for the use of the poor preachers, who were unable to own the manuscript of an entire Bible. It was thought, and properly, that it was much more easy to reach the comprehension of the masses from the view of a picture, than by reading and expounding of scriptural passages. A *fac-simile* of it is now in the British Museum. It is described as a small folio, containing forty pages printed on one side only, with the pale brownish ink used in most early prints, and by means of a rubber. The pages are so arranged that they can be pasted back to back; each page is divided into five compartments, separated by the pillars and moldings of an architectural design, which immediately recall the divisions of a church window; in the centre some scene from the gospels, and on either side are placed scenes from the Old Testament history illustrative or typical of the scene commemorated in the central design; both above and below are two half-length representations of holy men. Various texts are interspersed in the field, and Latin verses are written below the central compartments. It will be seen that the designs not only served to illustrate the preacher's lesson, but suggested the subject, and indicated and directed the course of his sermon; they taught him before they taught the people.*

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* George E. Woodbury.

There was another illustrated book which dates back to about the time of the publication of the *Biblia Pauperum*, and which has excited a vast amount of discussion as to its origin. It is known as the *Speculum Humanæ Salvationis* (Mirror of Human Salvation); and is rather larger than the edition just described of the *Biblia Pauperum*, having sixty-three leaves and fifty-eight pictures. It was probably issued about 1470. The discussion concerning it has been with reference to its origin, this being located in several varying directions; but the majority unite in ascribing its production to the artists of the Netherlands.

Wood engraving spread very rapidly until the beginning of the seventeenth century, when it experienced a decline. Its use, from about 1610 to 1833, was confined mainly to the printing of calico, and the production of figures on tapestry. To-day it occupies a front rank; and this fact is due mainly, if not wholly, to the advances made by American artists.

Wood engraving, as understood in its modern sense, is the oldest form of engraving; and is now in common use. It is otherwise termed Xylography; and consists in tracing or cutting certain designs on wood, which are then transferred to paper. The wood used for the best of work is boxwood, on account of its hardness and the fineness of its grain. A block is prepared by smoothing it, and then covering with a thin coating of white, after which the artist draws on the block the design to be engraved. The engraver then proceeds to cut away all the block except that portion covered by the lines of the design. It is then exactly like an ordinary type; the lines of the picture are all in relief, and if inked and a piece of paper be pressed on the block, the lines will be transferred to the paper; and the result is an engraving. A considerable portion of the engraving of a block is done

by machinery, especially where it is desired to produce an even, flat appearance, by the use of parallel lines. Frequently before being printed, the wooden blocks are stereotyped, or electrotyped, in which case, they and not the original blocks are placed on the press to receive the impression.

The uses to which wood engraving are put would almost fill a large volume if accompanied by full details. Among the more prominent is, of course, the illustration of books. To what extent this branch of the industry is in use needs not be described, for the reason that it is patent to all who are in the habit of reading the book issues of the day. Besides the use for books, there is the department of wood engraving which prints the thousand forms of bill advertising with which the country is flooded. Every fence in every city, every dead wall, every open space in any city or village bears testimony to the magnitude, the value, the utility of engraving on wood. The benefit of this universal distribution of the result of the wood engraver's art connot be overestimated. Any book whose pages are illustrated has an added value to the reader. If it be of geography, he learns more from a single picture than he can from pages of the reading matter. If it be of machinery, it is impossible that he should comprehend the technical details unless accompanied by an engraving of the machine described.

Metals in place of wood are used for engraving, and the process is known as plate-engraving. About the same instruments are used in the processes on metals as in the engraving on wood. In plate engraving, there are several kinds produced, such as etching, stipple, line, mezzotint, and aquatint, each of which is wrought in a manner peculiar to itself. As said, engraving on wood is performed by cutting away from the surface of

the wood all save lines which are to appear in the printed copy; in plate engraving, the exact reverse is resorted to to secure the end sought, the lines which are to appear in the printed copy being cut out of the surface of the plate, all other portions of the surface being untouched.

In etching, the lines are cut out, or "bitten" by the use of acids. The surface of the metal is first covered with a preparation of asphaltum and wax, made dark by the admixture of blacking. The desired picture is then made in the wax, each line cutting through to the plate; when the drawing is finished, a border of wax is raised around the plate, and diluted nitric acid is poured over it. In three or four minutes, this is removed, the plate is washed, and the lines appear, having been bitten by the acid.

Line engraving is a process in which all the effects are produced by lines cut in the plate, and in which all the varying effects are brought out by the depth and width of the tracings. Stipple engraving is a kind in which dots are used in place of lines; mezzotint differs from the others in the manner of working and in the effects. "In ordinary engraving the process is from light to dark; in mezzotint, from dark to light." By the operation of a machine, a burr is raised on the surface of the plate and which, if printed from at this stage, would give only a black surface. To produce the picture, the burr is rubbed away where light is required, and the indentations are made deeper where heavier shadows are demanded. Aquatint is another form of etching by which the result obtained has the appearance of a drawing in Indian ink. It is, however, a process which is now little used, or not at all, having been superseded by lithography, and chromo-lithography, which will be presently alluded to.

The metals used in plate engraving are copper and

steel, the latter having only come into use at a comparatively late period. Steel did not come into use until the present century, its hardness proving an insuperable objection. Jacob Perkins, of Massachusetts, discovered a process of decarbonizing steel, since which steel plates have almost wholly supplanted copper for the purposes of engraving. Perkins not only discovered the process of rendering steel soft, but he invented a method by which engraving on steel can be transferred. After the design has been cut on the soft steel plate, it is reconverted into steel, and a cylinder of decarbonized steel is rolled over it until the sunken lines of the plate are reproduced in relief on the cylinder. This is then hardened, and the designs in relief are then rolled into softened plates, and are, of course, *fac-similes* of the design which appeared on the first plate.

In taking an impression from the wooden block, the ink is evenly distributed all over the surface, and the paper is then pressed against it, the same as in printing from type; but in plate engraving the ink is so distributed that it reaches only the cavities of the lines. When the paper is laid, the ink is transferred to the paper, and the lines are the same as those cut in the metal. In taking impressions of a metal plate engraving, the process is vastly slower than in the cases of wood.

There is a third process for the transfer of designs, in which neither wood nor metal is used, but which now fills a very large place once occupied by wood and steel in metal engraving. It is known as lithography; and in this process stone is used as the bed for the designs. It is the invention of a German named Aloys Senefelder, a resident of Munich, who brought it before the public about the year 1798. At the outset, he simply used stone in place of copper, for the reason that he was

too poor to purchase the copper, and produced his pictures by etching. He was not the inventor of etching on stone, for this had been known in France as early as 1728; and in England in 1788, by William Blake, a painter, and who, by-the-way, has a very curious history. He was born in 1757, in London, and died there in August, 1827. He was the son of a hosier; was apprenticed to an engraver, and soon after developed some talent for drawing and for poetry. He tried a volume of poems on the market, but it failed wretchedly. He next conceived the idea of printing and illustrating them himself. He took copper-plates, and on these he drew the words and the illustrations in varnish, and then ate away the intervening spaces with an acid; by this means he produced a plate like a wood engraving, with all the letters and lines in relief. It may be said of him that although visionary—he believed that everything was "revealed" to him, including his process of engraving—and attracting no attention during his life, his genius was a grand and unappreciated one. "The time will come when the finest of Blake's designs will be as much sought for and treasured up as those of Michael Angelo." *

Senefelder was in the habit of using a crayon made of wax and tallow; and made use of etching to secure the end sought, on his stone slabs; but one day it occurred to him that he might make use of the repulsion between water and oily substances, and thereupon lithography was born. In brief, in this process, a design is made on the smooth surface of a block of limestone, with a greasy crayon. The surface is then wetted with a sponge, which the stone absorbs, so that when the roller of printing ink is passed over the stone, the only portions

* Flaxman.

which retain it are those of the design, the water in the stone repelling the grease in the ink. This is the principle involved; but the process, in reality, is much more complex than thus described. In taking an impression, the paper is laid over the drawing, and a heavy pressure applied, by which the ink is transferred to the paper. The process of printing is a slow one; the stone must be wetted before each impression, and the ink laid on, with the result that not more than a hundred impressions a day can be worked by a single press—although the rapidity depends very much on the size of the drawing. Latterly power-presses have been invented, with the result that the celerity of the work is vastly increased. This new method of printing spread very rapidly, and became a great favorite with artistic engravers. It has undergone many improvements, among which may be noticed what is called the transfer process. In this, the drawing is made with the greasy crayon on paper, and when completed is laid on the stone, and a pressure applied. The drawing, having an affinity for the stone, adheres to it, and the paper, being dampened, readily peels off, leaving the drawing on the stone; when it is treated the same as if it had been originally drawn on it.

Another and very important advance was the printing in colors from the stone; or what is known as chromo-lithography. In this process, different colors are produced in a single picture, each color requiring a different stone, and the different colors being the result of as many impressions as there are colors. So well-known are the chromos to be found in every house in the land, that there is no use whatever in attempting to describe their excellence, and how difficult it often is to distinguish the best of them from oil paintings.

There is still another branch of the processes.

lithography which is known as photo-lithography, and which is probably the most important of all of the lithographic processes in use. It is one which has several branches; but the essential principle of all of them is the preparation of a stone to which can be transferred an object which has been photographed on some sensitized chemical substance. It may be worth while to transfer an account of the Osborne process, invented by J. W. Osborne, of Melbourne, Australia, in 1859, and which is in very general use:

"He prepares a sheet of paper by coating one side with a viscid solution, consisting of a mixture of albumen, gelatine, and bichromate of potash; this, after being dried in the dark, is exposed under a negative of the original to be reproduced. The photographic positive picture thus obtained, is inked all over while dry by "pulling it" through the press face down, in contact with a lithographic stone to which an even coating of transfer ink has been applied. When the sheet is removed from the stone, the adhesive ink covers its surface, and nearly conceals the underlying photographic picture below it. This sheet is next placed floating on hot water, with the inked side upwards; the moisture and heat together effects a coagulation of the albumen in the compound organic film, while the gelatine portion of the same gelatinizes and swells. The sheet is now lifted from the water, laid flat on a slab, and friction applied to its inked surface by means of a wet sponge. The superfluous ink not needed to form the transferable picture is hereby removed; the sheet is flooded with abundance of warm water, dried, damped again slightly, and transferred to stone by simply inverting it thereon and pulling it through the press the usual way. When removed, the ink on the surface of the transfer sheet will be found to have passed over to the

stone, which is then rolled up and etched, after which it is ready for the printer." *

It is by this process of photo-lithography that the daily illustrated papers are furnished with their pictures. In the use of this process for such illustration, one of the salient advantages which it possesses is the speed at which an object may be lithographed, and made ready for the printing-press. Probably not more than a couple of hours may be required, so that it is possible to illustrate events by pictures within a very brief period after their occurrence.

There are other processes in connection with engraving that are of interest. One of these is known as Nature-painting, and was, at some period since its invention, in extended use. It has several branches, but the most interesting one is perhaps that in which the impression on the plate is obtained direct from the object which it is designed to represent. In 1847, Dr. Ferguson Branson, of Sheffield, introduced a process for electrotyping impressions of natural objects which had been formed by pressing them into gutta-percha. With molds thus procured, he also took casts of brass; and in a little time, it was thought that it would be possible to procure copies of natural objects direct on metal plates. At first, experiments were conducted with wooden blocks, as they are much softer than metal plates. Two blocks of boxwood were softened by being steamed, the object to be copied was laid between them, and the blocks subjected to pressure, with the result that when the blocks were separated there would be a perfect impression of the objects in the wood. By inking the blocks, and laying a piece of paper on them, there could be obtained a *fac-simile* of the object in

* Alfred H. Guernsey.

white, all the rest of the paper being the color of the ink.

In 1852, a very high development of this process was in use in Austria, by which impressions of natural objects were taken on metal plates. It had been discovered that any object, however delicate, could be impressed into the surface of steel, if desired, by means of rolling pressure, without crushing the object so imbedded, although an infinitely smaller amount would crush the same object if a flat pressure were applied.* The principle was applied to the copying of ferns, flowers and all such natural objects. In getting the impression of the objects, lead or gutta-percha was used as the body in which the object was imbedded, and from these, copper plates were obtained by the electrotyping process. But, strange as it may seem, it is not impossible to indent hard surfaces through objects much softer than the one by which the impression is made. "Who could have predicted that so tender and fragile a fabric as ordinary thread lace would have sustained a pressure of not less than ten tons, and come out from under such pressure comparatively uninjured, leaving its impression even on so soft a substance as Britannia metal; but how much greater is our wonder increased when we find the same result produced on copper and on harder metal, formed by its alloy with zinc, viz., brass; the yet harder German silver, iron, or tin plate; and more wonderful still, on what we are led to believe is the most dense and hardest metal in ordinary use, viz., steel!" †

What have thus far been described are among the more prominent, but are not all of the processes which are connected directly with engraving or some of its branches. There are still others which are used for

* Samuel Davenport. † Aitken.

various ornamental and industrious purposes, such as the printing of carpets, paper hangings, floor cloths (or oil-cloths), the ornamentation of pottery ware, or printing on glass, and the decoration of all classes of Britannia metal ware. The subject of engraving would fill a volume, or a score of them, should one attempt its history in all its details, and the enumeration of the masters who have exercised their influence on its development, and their principal achievements.

It would not be just to the great men who have been connected with the rise and progress of invention in engraving to pass over them without some slight recognition of their labors, and a word or two as to what some of them have done.

Italy was the first to seize upon the new art, and to afford us the earliest illustrations of its uses. Many were the engravings which the Italian artists had produced for the embellishment of books; but it was not until Albert Dürer took up the art, about the year 1500, that it advanced much beyond the crudities of drawing characteristic of the untutored races. There was but little in the nature of perspective, the details of the drawings were coarse and unfinished, many of these early attempts resembling very much the efforts which children make at pictures on their slates. It is said that it was in Florence that metal plate engraving was discovered by accident by a goldsmith, who had engraved a picture of "Peace." In order to observe better the effect of his lines, he filled them with a mixture of oil and lamp-black, upon which, by accident, there was laid a package of paper, and to which there was communicated the outlines of the lines cut in the metal. This suggested printing from metal, and in this way was the invention born.

Dürer's most remarkable works are his designs taken

from the Apocalypse, which consist of some fifteen woodcuts illustrative of the Apocalypse of St. John; but in all, he executed several hundred, the greater number of which have reference to the events and men of his own time. Hans Holbein, whose name has been mentioned elsewhere, was also an artist who took a high place as an engraver. He was born in Augsburg, just at the close of the 15th century, and early removed to Basle, where his greatest works were accomplished. Two of his works in wood-engraving have become famous; one of them is the "Dance of Death," and the other "Figures of the Bible."

During this period, France produced some great men of genius as artistic engravers. Jean Cousin, who was born in the first year of the sixteenth century, made his mark, the most notable of which is the "Entry of Henry II. into Paris." Salomon was another French artist who attained distinction. He must have been a very industrious worker if all be true that is claimed for him, there being not less than some two thousand cuts which are attributed to him. In England during this period, there were produced no names of note; at the close of the seventeenth century, this early development of engraving on wood became extinct. There had come a change in the religious opinions of men, and in many other respects; there was a time when a good deal that was old was disappearing, and this art, as it had so long existed, disappeared with them.

At the beginning of the present century, there was a revival, since which this class of engraving has held its own against all others, and had a popularity second to none of the methods of illustration. Some artists whose names have become household words, have been associated with its success, and its wonderful popularity. Among these may be mentioned Branston, Cruikshank,

Leech; and in our own country, Linton, Marsh, King, and many others.

Of the value which engraving in all its various forms has possessed as an educator, and in increasing the dimensions of the industries, nothing really needs be said. It is something which asserts itself, and needs no summary, nor arguments to enforce its claims. All recognize the difference in the worth of a book which has its topics illustrated, and one which lacks them. In a thousand cases, an engraving of a few lines will tell what cannot possibly be told in words so as to be comprehensible. In this direction alone engraving has been of a value that is quite equal to that of a printed page. It has been one of the most valuable assistants of the author in his attempts to enlighten the public. In this use alone its utility has been beyond estimate. A single word may be said of its uses from another standpoint. It has developed the love of the artistic of the nations to an extent as to width and depth which could have been accomplished in no other way. It has enabled people of every walk in life to become familiar with the great works of the great masters. People who could never by any possibility be in a position to see the works of Landseer, Murillo, Guido, Turner, Reynolds, Wilkie, Angelo, Raphael, and others, are now as familiar with them as if they were in condition to walk every day of their lives in the Louvre, the Luxembourg, the British National Gallery, and the galleries at Rome. The engraving brings home all the *fac-similes* of the great pieces of statuary, the marvelous paintings, the architecture, as one would see them who stands in their presence. It has broken down distance; it enables one who is too poor to travel to visit all the world at his own fireside. He can thus see the sombre façades of Westminster abbey, the dome of the Invalides at Paris, the

mountains of Switzerland, the falls of Niagara, the spires of Nôtre Dame, the seal fisheries of Alaska, the Kremlin, the huts and warriors of the Zulus; in short, there is no part of the world that he cannot see, at a cost which is next to nothing. Engraving, and after it, photography, has shortened distance so that a man may stand beneath his own roof-tree, and there will pass before him a panorama from which will be omitted no essential feature of all that is great or small on the earth, in the earth, or in the heavens.

CHAPTER XX.

AGRICULTURAL IMPLEMENTS.

JUST what was the first implement used by the first farmer is something which can be very closely guessed at. It was probably the limb of a tree with one of its forks cut off nearly at the body of the original limb, thus forming a rude sort of a hoe. With this a hole could be beaten into the ground in which the seed could be dropped, and with which it could be covered. In a little time, perhaps in the course of a hundred or a thousand years after the hoe was evolved, it may have occurred to some inventive genius to leave the portion of the short arm of the branch a trifle longer; and then he would have a plow the same in principle as the most elaborate in use to-day in the most civilized countries, and like those which are yet in use among some of the more primitive races. Of course, when the original inventor had gotten thus far, it would very naturally occur to him, that it would very much aid the manipulation of the new agricultural implement if some one should take hold of the long end of the branch and pull, while another had hold of the other end and pushed.

Not a bad plow this! The long arm of the branch was the beam of the plow; the short arm was the tail, or handle, and the projecting branch, which had been sawed off, and hacked to a point, was the plowshare. Not many acres could be plowed each day by one of

these; but the early man was not an energetic being, and was not over-anxious as to the amount of soil which he uncovered, and stirred up. It is quite likely that after he had invented the plow, and tested its capabilities, he turned it over to the ladies of the family, and gave himself up to the more masculine duty of chasing the deer, or of surprising, and clubbing to death the members of some tribe which lived across a stream, or on the thither side of some range of hills.

There were some little improvements to this original plow, but not many until iron became known. Then there were changes, but mainly of detail. The share was retained, but it was shod with an iron point. Perhaps it was discovered that two handles were better than one, and somehow one was spliced on the other, or a long, forked limb was selected, with a jagged branch running at right angles, the latter serving as the share, the other for the beam, and the two handles. Then a piece of pointed iron was added to the plowshare, and there was a model plow; one which attracted as much attention as the introduction of some of the most famous implements of modern times.

In thus tracing the evolution of the plow, it is comparatively easy to see that there came a time when the day was hot, the soil tough, and the shade of an umbrageous tree a desirable retreat. Then it was that one or the other of those two who were pushing and pulling the forked branch said, as he wiped tbe perspiration from his eyes:

"Kadosh, see yon bullocks in the shade! Stout, idle animals are they, with nought to do save chew their cuds, and hunt the cool shades and the waters in the heat of the day. Would they had to pull this wearisome plow!"

"Why not?" A bright idea strikes the also-perspiring

Kadosh. One of the gentlest of the bullocks is led up; a leathern thong is attached to his horns and to the end of the forked branch. And then with solicitations, objurgations, and with a bolt, balk, and tossing of head, he is led along dragging the branch after him. And thus is solved one of the great problems of utilizing force. And thus the bullock, the patient ox, and even the docile cow, came under the yoke, from which they have never since emerged.

At the Paris Exposition in 1878, there were to be seen plows from China and Japan that were but a very little, if any, in advance of the kind which has just been described. There was another kind, said to be in use yet in some parts of Scotland, which consists of a single stick, with one end thicker than the other, the latter being sharpened to cut the soil, and the other bending up in a curve to serve as the handle. That the plow is of the very highest antiquity needs scarcely to be said. It is often mentioned in the Bible, and is frequently mentioned by the ancient writers.

The plow used by the Romans is still in use in various parts of Europe. It consists of a beam, the handle, the share—which had in the meanwhile been evolved—the coulter, and a mold-board. That the Roman implement was not as rapid as its modern successor may be inferred from the fact that one-third of an acre was regarded by the Romans as a good day's plowing, in sod; and two-thirds in ground which had already been broken; in these days more than three times as much is easily accomplished by the skilled plow-man in average ground.

It seems to be the case that many other of the modern implements of farming were known to the ancients, that is, within a few centuries before Christ. They had

different kinds of plows for different soils; they also had rakes, harrows, hoes and spades.

When the tide of barbarism from the north overwhelmed the Roman empire, it extirpated agriculture, as it did many another institution of value, and for a time, save in Spain, agriculture almost disappeared from Europe. The Moors in Spain retained what little civilization there was is that portion of the world, and among other industries, they diligently cultivated the soil. But it was not till the eleventh century that anything worthy the name of agriculture made its appearance in any other part of the continent; and then it came to light in the Netherlands. The Romans taught the Britons something about tilling the earth, but this legacy was uprooted by the Saxons, whose beefy natures, gross and sensual, preferred the products of the chase rather than those of the earth for their sustenance. They kept large numbers of animals, and like some of their descendants, preferred the semi-raw beef and under-done mutton to any other edible which could be furnished them. "No hoed crops, or edible vegetables were cultivated, and even as late as the reign of Henry VIII., Queen Catherine was obliged to send to Flanders or Holland for salad to supply her tablo. Neither Indian corn, nor squashes, nor carrots, nor cabbages, nor turnips, were known in England till after the beginning of the sixteenth century. The peasants subsisted chiefly upon bread made of barley, ground in the quern or hand-mill, and baked by themselves. The tenant peasantry had no security for their property till after the fifteenth century. If the estate was sold by the landlord, they were obliged to quit all, giving up even their standing crops without compensation. They were liable for the debts of the landlord to an amount equal to their whole property, and it was not

till after that time that they were held only for the amount of rent due from them." *

It was not till the sixteenth century that agriculture began to take any prominence in Europe. The modern plow came from the Low Countries; and in fact, it was not till the last part of the last century that England began to supply her own wants in this direction. At first the mold-boards were made of wrought-iron or steel, which were changed to cast-iron in 1784, by a Scotchman named James Small. During the earlier portion of our history, we used mold-boards covered with sheet-iron. The first cast-iron plow patented in this country was by Charles Newbold, of New Jersey. Thomas Jefferson, politician that he was—president, statesman, ally of France, and all else—gave a good deal of time to the principles on which a plow should be constructed, and finally reached the conclusion that the proper shape of the mold-board, should consist of "a lifting, and an upsetting wedge, with an easy connecting curve." Since that time, an almost infinite number of improvements, real or alleged, have been given to this implement, although every one of them still adheres with wondrous fidelity to the very first principles in the construction of the first forked branch with which our very remote ancestors prepared the ground for their scanty crops.

The almost infinite variety of plows in use can be inferred from the fact that, at the Paris Exposition, in 1878, there were over fifty varieties on exhibition, and this is very far from including all the kinds that are in use. There were those with wheels of equal size, and of unequal size; those with one wheel; those with two wheels and a skim coulter; with revolving coulter;

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* *Am. Cyclopædia.*

rod-beam plows; with turning mold-boards; double plows; plows for subsoiling, for trenching, for ridging, clearing; and, in fine, almost every conceivable purpose. There were sulky-plows, gang-plows; some which cut two furrows at once, some which cut three, and even some which rose to the dignity and reponsibility of plowing four furrows, and even six, at the same time. There were still other varieties under the head of potato-diggers, leveling implements, beet-root pullers, and ingenious appliances for the performing of the less heavy class of work. At this exhibit, the United States was well represented by the Michigan Rod-beam, Iron-beam, the Gilpin Sulky; the gang-plow, by Deere, of Moline, Ill.; the Center-level, the Hillside; the Potato-digger, by Speer & Sons of Philadelphia; and still others by other Americans. It may be added, that in some test, which took place between some American and French plows the mean was in favor of the American.

An American plow which has attracted a good deal of attention is Austin's rotary plow, patented in 1879 and 1881. The ground is turned by a revolving disk of steel, set vertically. The disk is dishing, the concave side being towards the side to which the soil is turned. Each plow has two disks, which turn each from twelve to fourteen inches in width. This implement is very efficacious in the breaking up of all except sod surfaces, and pulverizes as it breaks up the ground.

In the matter of plowing by steam, the English are far in advance of all other nations; and it is scarcely necessary to add that we are not only far behind England, but every other nation of any consequence in Europe, in the use of steam for plowing. This is the more remarkable in view of the fact that there is no country in the world which is better adapted than this for the use of steam in this direction.

The attempt to plow by steam dates back to the last century when, in 1769, an Englishman named Francis Moore, took out a patent for a machine which would plow without the use of animals of draught; and in 1810, Major Pratt, also an Englishman, patented a process for the use of two steam-engines, one on each side of the field to be plowed, and which should draw the plows across by means of an endless rope. For some reason, Pratt's plan did not work, and plowing by steam remained in abeyance until 1832, when a member of Parliament patented the first successful steam-plow that came into use. Mr. Heathcote's plow proved that it would do the work required of it; but it was very cumbersome, and required not less than ten attendants to manage it. This original attempt has undergone many improvements, until now when there are hundreds of steam-plows in use in the Old World. There have been considerable time and effort expended in attempts to secure traction engines which would cross the field to be plowed, dragging the implements after them, but with no substantial success. There may be two or three in use in this country, but they are not regarded as of value.

There are various methods of utilizing the steam-engine for plowing; one being the traction-engine just mentioned, and others, in which the engine remains on one side of the field to be plowed, while there is another engine, or simply a truck, on the other side; the plows being pulled from side to side by a chain or rope. In all cases the plow is a double-ender, that is, two sets of plows arranged end to end together. When a start is made, the front plow is raised by a lever above the ground, and the rear set plows across the field; when the other side is reached, the place of turning about, the rear set is raised from the ground and the front ones

lowered. There is still another method of dragging the plows from side to side in which there is a single engine, a series of ropes stretched about the field on bearers so arranged that by shifting the bearers the plow can be drawn in any desired direction.

There are in use in England and Scotland alone more than three thousand cultivating engines; in Egypt more than five hundred; in Germany and Austria several hundreds, besides others which are in use in the West Indies, and in South America. In Great Britain, many of these appliances are owned by the proprietors of the lands, and by some of the more prosperous tenants; but there are several companies which plow for hire, in all probably not less than one hundred and twenty-five, some of whom have as many as twenty full sets of the engines and all appliances for plowing. The advantages of plowing by steam is that deeper work can be done, and much more rapidly than by the ordinary methods. One steam-plow in crossing a field once, performs the same work that would be done by twelve horses drawing six plows, and in half the time; which is equivalent to doing twelve times the work of a single plow drawn by one span of horses. In England it is estimated that the saving of steam over animal plowing is about one hundred and sixty-six dollars for each one hundred acres.

There is a good deal of romance connected with the ordinary plow, such as is drawn by horses and guided by hand. It is especially so in the eastern communities, in which few or no new fashions are known in farming; where the flail, and the tramp of the horses still threshes out the grain, where the corn is pulled from the stalk and husked in the barn in the cool of the autumn evenings; where the grist is carried to the mill in a bag thrown across the back of a horse, and on which is

seated a boy too young for the harvest field, but too old to be idle. It is in such communities as these that plowing is not only a science, but an art, and withal is artistic. Who that has ever lived in one of these drowsy communities, with its weekly or possible semi-weekly mail, its old church on the hill, its school-house at some cross roads, its inn with its faded sign, and its "store" smelling of codfish, pickled mackerel, and its empty, fly-covered sugar hogsheads, does not remember that there was always one young man among the sons of the farmers who ranked among the plowmen of that section as Raphael among painters, or as Napoleon among captains.

There was no such thing as rivalry. His place was conferred him by unanimous consent. He was something to imitate, to be used as a model; but nobody ever aspired, in his neighborhood, to even permit the suggestion of being a rival. Away over the hills, from another community, there came rumors of another great artist at the plow; but his pretensions were laughed to scorn. Men sat by the blazing stove within the "store," in the winter, and on the cool "stoop" in the summer evenings, and as they whittled, they apotheosized their own champion of the plow, and treated with derision and scorn the claims of the rival.

As he walked to church on the Sabbath day, he was the recipient of many a kindly glace from the plump girls, and of admiring ones from the young men as they looked at him as something superior to the average man.

But what a triumph was the exhibition of his art! To see him "strike out a new land" was almost as good as a circus. He steps off his seven paces, and drives a stick in at the top of the last step, and to it he hangs mayhap a perspiration-drenched handkerchief of no

particular color; half way back to the other end of the field, seven paces from the ridge of the last "land" there is another stick. He swings his plow about at the beginning, or on the "headland." He is not the least excited on the eve of his crucial endeavor. He brings the point of the share until it is exactly in line with the two sticks across the field. The horses are guided until the artist sees between them the two guide-posts which he has erected. The handles are lifted, the share cuts into the earth; the keen coulter cuts into the green sod as a knife into a yielding cheese. And now he is off! His eye is on the nearing stakes; the reins across his neck and under one arm, are held taught, and the docile animals move as if they were machines gliding on rails. The first stake is reached, the share cuts it at its very centre; a little later, and it cuts the stake on the further headland with the same exactitude—and the great artistic feat is accomplished! Glance along this new furrow; a rifle ball fired from a gun is no straighter in its course; the landside has left a wall that is as unvarying in its directness as the masonry of the foundations of a temple. The upturned sod lies squarely on its back as an inverted brick, and is as exact as to height, breadth, and width, as if cut out by unerring machinery.

When the "lands" are completed, every furrow is of the same exact width; the surface is as level as if it had been planed down and sand-papered, the lines between them are as straight as if they had been ruled, and the little ditches between the "lands" are of the same width, the same depth, and are as square, as neat, as if they had been laid out with a line and finished with a trowel. This *is* plowing; and this is the artist who executes the work. It is this man who manipulates the four-legged "marker" which designates the rows of corn. He lays

out the rows with all the squareness of a great chess-board; when the leafy plant reaches above the surface, each hill has an alignment with every other hill, such as is to be seen only in a crack regiment, when the soldiers have "guided left," and have come to "eyes front" in a line that is without a waver, or a variation.

When that useful implement, the flail, first came into existence, there are no accurate historical data for determining; but it probably made its appearance about as soon as there was anything which needed threshing. It is mentioned in the Bible, and probably was in use among the historical races. As for the scythe and the sickle, it is not likely that they were very much in advance of the flail. They have been much supplanted, in late years, by the use of the reaping and mowing machines, and the machine-thresher. We read in the Scriptures that "thou shalt not muzzle the ox which treadeth out the corn," from which we may be permitted to infer that a method of threshing still in use, originated in its present shape at least four thousand years ago.

The scythe and the sickle were originally weapons of war as well as of peace. The same weapon which was used to hew down an enemy was also employed to level the stalwart wheat or barley. They were in use from time immemorial, and they are substantially the same now that they were in the beginning, with the difference that modern civilization has found speedier and more effective methods of killing; and hence, leaves the scythe and the sickle to the peaceful pursuits of agriculture. The earlier scythe was a curved blade, fastened at right angles to the end of a straight stick. In deference to aching backs, the handle or "snath" was bent so that less effort on the part of the wielder gave greater results. The broad strip of iron, known as the "back" of the scythe, is a very modern invention, being

that of a Yankee named Joseph Jenks, at Lynn, Mass., in the year 1640. When to the scythe there were added

THE SICKLE.

the fingers, and the whole became a "cradle" for the cutting and laying grain in swathes, with the head of the grain all laid in one direction, cannot be stated; but

THE CRADLE.

it must have been a Yankee invention, for it is not to be seen in any other country. In England, and in all

parts of Europe, where machinery is not used, the sickle is still the instrument for the cutting of grain.

The forging of scythes was once a very important industry; but the introduction of mowers has undermined it so that it is now but the shadow of its former self. The cumbrous cradle is fast getting to be a machine of more value to the antiquarian than to the farmer, although it is far from being extinct. There are tens of thousands of farms in this country which are so broken that they cannot be reached by the reaper; in the cases of these, the cradle must always remain of practical value.

The first reaping-machine which is spoken of in history is one which was alluded to by Pliny, as being in existence in about the year 64 of the Christian era; and which was used, according to these writers, in Gaul. It consisted of a cart which was pushed by an ox, with a species of comb in front that caught the heads of grain, tore them loose, when they dropped into the body of the cart. During the International Exposition in Paris, in 1878, one of the daily newspapers, in speaking of an American machine on exhibition, said: "It was the Gauls, our fathers, who, says Palladius, made the first reaper. The description given by him indicates a sort of cart furnished with two wheels; an ox in the reverse direction in the shafts pushed the machine like a wheelbarrow against the wheat. The edge of the cart was armed with a comb having long teeth, where the ears were caught and cut off by the edges of the knives and tumbled into the body of the cart. The straw remained after the ears were removed, or was either left in the field or gathered later.

"The reaper set up in the American section of the Exposition was made by the Messrs. Case, of Wisconsin, and is the Gallic reaper; perfected, it is true, but based

on the same agricultural system pursued for ages in some portion of China, where they reap by two operations, first with a sickle to gather the wheat, and then with a scythe to save the straw. The machine of Messrs Case, of Wisconsin, disturbs all our ideas of progress in harvesting by machinery.

REAPER IN GAUL. (A. D. 64.)

We have carefully examined it in the shed where they have carefully hidden, along the Avenue Souffren, the magnificent American and English agricultural machines, as if they did not merit a place in our exposition . . . We cannot, however, neglect rendering our homage to the truth, in declaring that it is to this side of the grounds that agriculturists and manufacturers should turn their attention." *

From the time of Pliny and Palladius to the invention of the next reaper, there is a very long interval, one

* *La France.* May 28, 1878.

of almost eighteen centuries. According to Knight, the next suggestion of a reaper was that of Pitt, in 1786, who constructed one in which there was a cylinder, with combs attached, which caught the ears of grain, broke them from the stalk, and dropped them into the cart. Then there was no especial improvement for a time, inventors turning their attention to securing some means of cutting the grain by attaching revolving knives to the axle of the wheels which bore the body of the machine. The first reciprocating knife was invented and put in use in 1822, up to which time but four inventors had employed the horses in any other way than at the rear of the cart. The side-cut mower, that is, one in which the horses walk alongside the grain to be cut instead of in front, or behind it. This was in 1806; the invention was that of an Englishman named Gladstone, and the cutters were revolving knives. In 1822, Ogle, an Englishman, gave to the world the reciprocal knife-bar; the horses moved in advance; there was a platform, there was a reel to tip the grain towards the cutter. This contained many of the principles of the modern cutter. Four years later, another Englishman added some improvements; his machine had knives which vibrated on pivots; it had a reel, and a traveling apron which took the cut grain and delivered it at the side. Two years later, Samuel Lane, of Maine, made a combination of the reaper and the thresher. In 1833, the well-known Hussey, of Maryland, constructed what has been termed the "first harvester of value. It had open fingers, with the knife reciprocating between the space. The open-toped slotted finger was patented by Hussey, in 1847. The cutter-bar was on a hinged frame." *

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* Dr. Edward H. Knight.

The next harvester of importance was that known as the McCormick. This harvester has played so large a part in the history of agricultural machinery that it and its inventor are worthy of some special mention.

Cyrus H. McCormick is the eldest son of Robert McCormick, was born in Rockbridge county, Virginia, in February, 1809. His father and mother were both natives of Virginia, and were of Scotch-Irish descent. The son did not receive much schooling, and gave his time to assisting his father, who was a farmer, and who owned some farms, grist-mills, and who had all the shops necessary for the repairs of the machinery in use upon his property. Thus the young man had about him a large industrial school, into which he could enter at will, and from which he graduated in time with very high honors. At the age of fifteen, he gave evidence of his mechanical aptitude by the invention of a "cradle," and which was used in the harvest field. He came by his mechanical genius legitimately, for the reason that his father was an inventor who made several important mechanical discoveries, among which was a reaping machine which he brought out in 1816. It did not meet, however, with the success which he anticipated, and, being for the time discouraged, and much occupied with other matters, he laid it aside, and did not take it up again till 1831. His machine was very elaborate, and very ingenious and complicated; the only defect in it being that it would not work.

Young McCormick's first invention after the cradle was a side-hill plow for always throwing the furrows down the hill; and was followed, two years later, in 1833, by the invention of a self-sharpening, horizontal plow. During the period anterior to his invention of the side-hill plow, he had been watching very closely his father's efforts to invent a reaper. It occurred to him that his

father, in attempting to separate the grain into small bunches before cutting, had made a mistake; that the grain should be cut as a single body, the requisite motion to the cutting apparatus to be supplied laterally by a crank attached to a reciprocating blade.

While he was thus engaged in experimenting with his reaper, he went into the smelting business, but did not succeed owing to the financial crisis in 1837. In 1834, he took out patents for his reaper; but it was not until after his failure in the smelting business that he gave his whole attention to its manufacture. In 1845, he removed to Cincinnati, and during that year, he took out another patent for an improvement; and still others in 1846–7–8. At this time his machine was being manufactured on a royalty by several firms in various parts of New York. In 1847, he resolved to establish himself in Chicago, where he entered on the manufacture of his reaper.

The varieties of reaping machines in existence are almost infinite. They are light or heavy; they are adapted for the cutting of grass, for the gathering of the heads of clover; for the cutting of wheat, oats, and other grain, with, or without binding. As to names of the various styles of reapers, there are Woods, the Champion, Manny's, the Osborne, the Aultman, all being binding reapers; and mowers such as the Buckeye, New Champion, two of the Woods patents, all of which are American; and scores of others the product of other nations.

The chronology of the reaper and mower is as follows, according to Knight: Pitt, England, 1786, which stripped the head from the straw; Boyce, 1799, six rotating scythes, and first reaper patented; Plunkett, 1805, horizontal, rotating circular blade, (the first machines used in England in 1811, and in use for a considerable

time, being of this pattern); Gladstone, 1806, front-draft, side-cut, revolving knife machine; Salmon, 1807, vibrating knives over stationary blades, fingers to gather the grain to the cutters, and a rake suspended to carry the grain off the side; Ogle, 1822, first reciprocating knife-bar, and although poorly constructed, the "type of the successful machines." All the machines thus far mentioned were British.

SELF-BINDING REAPER.

Bailey, American, 1822, mowing-machine with revolving scythe; TenEyk, 1825, horizontal cylinder, with spiral knives cutting against straight edges; Samuel Lane, Maine, 1828, combined reaper and thresher; Manning, 1831, row of fingers and reciprocating knife; Hussey, Maryland, 1833; McCormick, Virginia, 1834; Randall, 1835, pair of knife-bars reciprocating past each other; Briggs and Carpenter, Moore and Haskell, all of America, and Ridley in Australia, 1836, combined reaper and thresher; Knowles, 1837; Wheeler, 1838;

Lamb, 1840; 1850, Heath, binder; Watkins, 1851, automatic binder; 1871, Barta, binder; James F. Gordon, binder, 1872–74; and among other binders, Carpenter, 1868; Fowler, 1870; Clinton, 1869; Bowron. Chapman, and Withington, 1872; and Whitney, 1874.

The reaping machine of to-day is the result of numberless improvements which have been made to the machine invented and in use from 1833 to 1836.

There is danger that the introduction of so much labor-saving machinery may tend to make men effeminate. The fire-wood which was once chopped is now cut by a "buzz" saw, driven by horse-power. The rails which were once split with ax, wedge, and beetle, are now displaced by boards sawed at the mills, or by a barbed-wire fence, into whose construction no manual labor enters. Once a man marched between the tail of the plow from "sun-up" to sun-down; he swung his implement about the stumps, and the stones; the sun shone on him, the winds beat against him, and he grew broad and deep of chest, mighty as to thighs, muscular as to arm and calf, and active as to step and movement. Now, when he goes out to plow, he feeds the boiler of an engine which befouls the air which environs it, or he mounts a seat on the "gang," and all the day rides with stooped shoulders and contracted chest.

But it is in the harvest field where he is becoming effeminate. Once the man who went out to swing the scythe or the cradle for the livelong day, was a man in the fullest sense of the word. There could be nothing spindling or weakly in the muscles which for twelve hours at least, beneath a broiling sun, were to drive the scythe through the matted grass, or swing the ponderous cradle—a load for the modern man—through the heavy wheat, or the tasseled oats. It demanded brawn, chest, endurance for this labor. Now, when a man

wishes to cut his grass, or garner his wheat, he mounts a cushioned seat above a confusing composition of platforms, cranks, oscillating knives, cogged wheels, chain-belts, and levers, and drives a-field as if he were taking a drive for health or recreation. The distance echoes the clamor of the reel and the rattle and clang of the groaning machinery, as if complaining that its peaceful silence were outraged by this noisy interruption. A dwarf, a man with shrunk shanks, a man with the consumption, with the asthma, with the rickets, with a hump, with the dyspepsia, with atrophied muscles, with rheumatism, with any and all of them, is just as good to drive a mowing machine as if he had all the development of the ancient gladiator.

Once, the stalwart timothy, the fragrant clover, the wheat with head drooping with the weight of its contents, had at least the satisfaction of knowing that if it must fall, it went down before one who was worthy to administer the blow. But now, a piping-voiced boy, a hop-o'-my-thumb, a manikin, a runt, a tomtit, can mount the seat of the reaper, and do more in one hour, in doing nothing, than the Hercules of yesterday could accomplish yesterday, with all his splendid development. Nor is this all there is of this tendency to physical deterioration. Like all of their class, the reaping machines obliterate all the romance of the farm-life. Time was when to be a farmer, one was obliged to be a whole man; now he requires only sufficient brains for the management of a few machines. The boys will not remain at home to play second to these insensate machines, and they go away to the cities or the mines, and—are lost.

Once there was no slavery in the farmer's household. Himself and his sons, his wife and his daughters knew no dishonor in labor. They rose with the dawn; they labored till the twilight; they went to bed betimes,

and slept dreamlessly and restfully the night through. But the machine has come, and muscle and brains are no more required. The tramp from the city is as good a farmer as the best of them; he can mow, and reap, and thresh in an hour as well as the men who, under the old regime, demanded years of experience to perform the same work. The power-loom has left nothing for the girls to weave, the "mule" has left her nothing to spin, the sewing machine has left her nothing to sew, the baking-powder has left her no bread to make, the patent wringer no healthful exercise over the wash-tub. She has nothing to do, she acquires a little French, she paints a plaque or two, drums a little on the piano, and less on the guitar, warbles a trifle; and then is ready for the matrimonial market.

As machinery comes into use, the business of farming becomes more and more like the operations of a factory. There are cheap operatives who are of the grade of the "hands" in the mills of the cotton manufacturer; these require only an overseer; the owner may reside where he will. With the power, by the aid of machinery, to do so much more work than by hand, there comes a demand for larger farms; the smaller proprietors are being absorbed by the larger ones, until the drift is toward a state of things in which the small farmer is the exception, and the large ones the rule. With this state of things comes the debasement of a class. In Great Britain, the farm laborer is the most degraded, in point of social position, in the kingdom. The introduction of machinery creates intense competition, and thus prices and wages are lowered.

It may be that the average nation is elevated. It may be that the demand for machines, while it may have a ruinous effect on the status of the farming community, may give work to a larger number in the

increase in the farms opened to cultivation, the demand for labor for the construction of the machines, and in men and ships for the handling of the increased product of agriculture. But while this may be the fact, it is still true that farming by machinery has the effect to destroy the solid family relations of the old farming communities, to weaken the anchorage which these elements afforded for the shifting morality, political or otherwise, of the nation, or the communities; and to take from us much that is desirable, and give us something which, while more glittering and showy, is, nevertheless, less substantial and less valuable.

Thus far, but a comparatively small portion of the machines in use in agriculture have been described, or even enumerated. There are machines for the pulling of stumps; there are others for the sawing down of trees; butter is made, and cows milked by machinery. There are mechanical processes for planting, for pitching hay on the wagon, for unloading it at the hay-mow and the stack. There are reversing and revolving hay-rakes all to be moved by horse-power; there are horse tedders for the stirring of the hay in the new-laid swathe; there are threshing-machines from those that work by hand up to those of many horse-power; there are machines for stacking straw; there are hullers for clover and other seeds; there are separators without limit; there are sorters for separating mixed grains; there are a dozen kinds of machines for the removal of stone and sod from grain; there are straw-cutters, grain-flatteners, grain-crushers, kibbles for cracking grain, oil-cake breakers, root-washers, potato assorters, root-cutters, root-shredders, root-diggers, grape-crushers, hay and baling apparatuses without number, hedge-cutters; and after all these have been enumerated, the list of the machines in use has scarcely been begun. In France, an

inventor named Albaret, of Diancourt, has produced an electric light by which farming operations can be carried on by night as well as by day. He attaches to the locomotives which furnishes the power, a Gramme machine, and erects a mast some sixty feet high, which is fixed on the engine, and which carries at its top an electric light. The same engine is used at the same time for plowing or threshing, or whatever may be the work in hand.

The threshing-machine plays an important part in agricultural operations that it deserves a word of special mention. The inventor of threshing by machinery is due to a Scotchman, named Andrew Meikle, in 1786, in East Lothian. There had been previous attempts in 1758, to produce a machine for the threshing of grain. One of these, that of Menzies, at the earliest date, was composed of a series of revolving flails; and the other, that of Stirling, had a cylinder "with arms upon a vertical shaft, running at high velocity." There followed an English improvement on the Scotch invention, and this again was improved on by American inventors. In the American machine, there is a concave, having teeth, close to which revolves a cylinder having also teeth. The grain is fed so that it passes between these teeth, and is thus separated from the straw. The English thresher is the same concave or breast, and cylinder, without the spikes or teeth. In 1853, an American thresher competed with an English one at Kelvedon, England. The American machine did more than three times as much work in the same time that did its competitor, and left the grain in a much cleaner condition.* The same writer from whom these facts are obtained, and who was one of the two men who took the machine

* Edward H. Knight.

over and operated it, quotes from an article in the *Times* of London, and which, speaking of the competition, says of the American machine:

"This machine, which is portable, weighs only fourteen hundred-weight, threshes easily, and without waste, at the rate of one bushel in forty seconds, and turns out the grain perfectly clean and ready for the market. It is, therefore, about twice as light as the lightest of our machines of the same description; does as much if not more than the best of them, and with much less power, dresses the grain, which they do not, and can profitably be disposed of at less money than our implement-makers charge. . . We build threshing-machines strong and dear enough, and tremendously heavy either to work or draw about. The American farmer demands and gets a machine which does not ruin him to buy, or his horses to pull about, which runs on coach and not on wagon-wheels, and which, without breaking the heart of the power that drives it, yields the largest and most satisfactory results. Nothing, therefore, can better illustrate the difference in the mechanical genius of the two countries than this grain-separator as compared with its British rival."

It may be remarked that the English system of threshing does not injure the straw as much as the American one; and on this account is preferred by the English farmer, for the reason that there is a quite important market for straw in that country.

In the competition which took place between the various kinds of power-threshers, in Paris, in 1878, the United States gained no honors. This was owing in part to the fact that the American machines bruise the straw, and "because our machines were not managed by parties familiar to the work. . . . The jury was principally French, and, of course, acted on the judgment of

European requirements in such machines. Ours did not suit the country, though there are places in Europe where they might be successfully introduced; but not at present among French or English farmers.*

In the matter of winnowing machines, or separators, or fanning-mills, as they are often termed, the French seem to be considerably in advance of all other nations, if one may judge by what was exhibited at the International Exposition, in Paris, in 1878. It may be that their superiority is to be found in the fact that there is a greater necessity for such machines in that country than in any other. In the words of the United States commissioner: "They (the French) frequently sow and harvest two crops together, such as oats and vetches (tares) for instance, and then sort the threshed results. The crops seem to be more harassed by weeds; the common red poppy, the wild vetch, the cockle seem to be ineradicable from the wheat. . . The methods of harvesting are somewhat slovenly. The crops are cut with the sickle, cradle, or scythe, lie on the ground to cure, and the result is that stones and clods of dirt are very common in the threshed grain. Even the threshing increases the quantity of this foreign matter, for it is largely done in installments on the soil floor of barns and sheds."

There are no less than eight of these machines in use among the French, whose uses may be gathered from their names:

Tarare, blast-fanning-mill; *Aspirateur*, suction-draft fan-mill; *Nettoyer*, cleaner; *Cribleur*, sifter; *Trieur*, sorter; *Epierreur*, stone-remover; *Emotteur*, clod-remover; *Diviseur*, separator

* *Reports of the United States Commissioners.* Vol. v., p. 175.

In addition to these there are combinations in which two, and even three of the kinds just mentioned appear. For instance, there is one of these combinations which is known as the *Cribleur-trieur-diviseur*, or a sifter-sorter-separator all in one. In the ordinary fanning-mill in use among many of our farmers, there are the sieve, the blast of wind, and the shaking, lateral movement of the frame containing the sieves. The French use the blast, the same as in the fanning-mill, the aspiration, in which the air is "sucked" in, and percussion. The *tarare* is almost exactly like the American fanning-mill; but the *tarare-aspirateur* is one in which the air is drawn in and passes through the grain before it reaches the revolving fan, and which deposits the heavy grains in one place, the next heaviest in a second place, a third, still lighter, in a third, while the chaff and dust are carried off in the usual manner.

The processes in use in these various machines are interesting, but need not be described in detail. Suffice it that none of them are as simple as the original method in which the grain to be winnowed was gathered in a heap, and then tossed up in the wind, to be cleared of chaff by this simple agency.

Agriculture in this country is yet in but its infancy compared to what there is every reason to hope it will be in a quarter of a century. At least one-ninth of the total population is engaged in agriculture, of whom one-half are proprietors. The cash value of the farms of this country is fixed at over ten billion dollars, and this, despite the fact that only one-half of the tillable land has been brought under improvement. The exports of agricultural produce reaches up to an annual sum which in some cases has been nearly a billion dollars. The average crops of a fairly good year may be estimated to

amount to considerably over a billion and a half dollars; a sum which, in two years, would pay off the debt incurred by the nation in the great civil war.

These statistics have reference to a country of whose land only about one-half is under cultivation; and which, where cultivated, is very far from producing such crops as it would, under a more scientific mode of farming. Supposing all our land under cultivation, and scientifically managed, we should have a result each year of something like ten billion dollars. In England, the amount of capital invested in farming is something over one billion dollars; the rent of farms about three hundred million dollars. If this country should carry on farming as carefully and economically as in England, the result would be a sum so large that it would be incredible. In England, agriculture receives as much attention as any other science. There is an improved and comprehensive system of drainage. Artificial manuring is resorted to; and in fine, every expedient which science can invent is employed to produce the very last possible yield from the soil. In this direction, this country is advancing with great rapidity. The old style, hap-hazard, do-it-as-your-father-did-it-because-he-did-it, is going out of use, and is being replaced by all that can be suggested by a ripe and intelligent experience, and that science can contribute to the end in view. The government is taking an active part in aiding this improvement. As yet land is so plentiful and cheap, that men can produce all they can care for with but little trouble, and thus are more extravagant and careless than they will be at the end of the next quarter of a century. In fifty years the magnitude of our annual agricultural products will be simply stupendous.

There is not very much work for the inventor at the

present moment, in the department of mechanical devices for use in agriculture. In the department of chemistry, there is an ample field for discovery; and it is here, and not in mechanical appliances, that invention should apply itself for the next quarter of a century. Possibly there is one exception to this, and that is, that there should be invented some shorter method of getting grain from the producer to the Atlantic, or to shipping points.

CHAPTER XXI.

FIRE-ARMS AND ORDNANCE.

IN the chapter on gunpowder, some allusions were made to weapons of war, and modern improvements in weapons of offence and defence; but there was nothing said which covers any considerable portion of the ground to which these agencies are entitled by their importance.

In their very earliest existence, men probably fought each other with clubs, sharp flints, and such other implements of offence as were found ready fashioned at hand. The earliest weapon known is the bow. It is spoken of in the Scripture, and is known to have been in general use among oriental nations. Among the Greeks and Romans, the bow was not used, except in the cases of some of the mercenaries. Among the Romans and the Greeks, the pike, javelin, and a short, two-handed broadsword were in use, the latter being the weapon which the Romans most valued, and with which they secured most of their victories. In the formation of the lines, the Romans had intervals of six feet between the files, which gave each man ample room to manage his sword and buckler; the sword being used mainly as a weapon for thrusting instead of cutting.

After the fall of the Roman empire, the lance came into use. It was made of wood; was eighteen feet in length, with an immense butt whose weight counterbalanced that of the body of the weapon. This implement

was the weapon of knighthood. Its bearer, clad in impervious armor, mounted on a powerful horse, with lance in rest, was able to ride down the unarmored ranks of footmen with little danger to himself. In addition to the lance, the knight had a mace and a battle-ax, a dagger, and the huge, two-handed sword. At this time, the infantry were armed with bows, bills—a short, heavy scythe set on the end of a pole; leaden mallets, long knives, pikes, halberds, cross-bows and spears. All these were in use till 1525, when at the battle of Pavia, fire-arms were introduced; and then was established a dividing line between ancient and modern weapons.

Of all the weapons used by the ancients none were so effective as the bow in the hands of the English archer. Every reader is familiar with romances in which the English bow plays an essential part, and of battles in which it decided the victory. It was brought into England by the Normans, who had obtained it from some of the Norse tribes. Its regulation height was that of the bowman, and the arrow was half the length of the bow, or about three feet, and thus obtained the name of the "cloth-yard shaft." Some of the tales which are narrated of the skill with which the bow was handled, would prove that even the best of the sharpshooters of modern time, with their weapons of precision, are in no respect superior to the experts who twanged the bow of yew in the days of Robin Hood, and his "merrie archers." To hit a branch a half an inch in thickness, set upright at a distance of three hundred feet, was considered a feat of no extraordinary character. As to penetrating power, it was not an uncommon feat for an English archer to drive a shaft clean through a breast-plate of steel, and through the body of the knight behind it.

The cross-bow was in the hands of some of the nations a weapon of much value. It was a short steel bow, fastened at the end of a wooden stick, or barrel, the barrel being split so as to permit the string of the bow to move easily through it. In some cases, a winch was used to draw the string back till it caught a species of trigger; the bolt was then inserted, and the bolt discharged by springing the trigger. In fact, every boy in the land is familiar with the construction of the ancient cross-bow, and it is now found as a toy weapon in every part of civilization. There was also the catapult, which was a species of huge cross-bow, used for the launching of heavy darts, or stones from the walls of a beseiged place on the enemy below. There was also the battering-ram, which was used for making breaches in the walls of a hostile city, and which was a huge, metal-shod beam, suspended at its centre by long chains, or ropes fastened to the upper portion of a movable tower. This tower served the double purpose of protecting the soldiers who accompanied the ram, and of carrying archers, who, as the tower was always higher than the walls, were able to fire down on the enemy who manned the portion of the defence that were being attacked.

The classes of weapons in use among the ancients were but few; they were implements to stab, such as the sword, spear, pike, javelin, lance, dagger; to cut, such as the sword, the battle-ax; and to beat, bruise, or crush, as the mace, the flail; to cut and to stab both, as the halberd, the guisarmes, the gauchards, the swords, and many others. From this limited number of classes there came an almost infinite number of individuals, different in shape, in name and material. Of swords alone there are innumerable patterns. There were the scimitar of the Moors, the short double-edged *spatha* and the *parazonium* of the Romans; the keen double-edged

scramasax of the Franks; the scores of varieties of swords worn during the middle ages, and other kinds not necessary to mention. There were still other weapons, some of which are still in use. There are the lasso, the boomerang, the blow-tube of the Malays, the *wummera* of the Australians, which is a piece of straight wood, "flat, three feet in length, having at its extremity a tube of bone, or a piece of tough skin in which the extremity of the dart is placed," and by which the dart is thrown a considerable distance with great accuracy; and the *rackumitick*, a species of javelin, to be thrown from the hand of the Hottentots.

As said, the battle of Pavia, fought in 1525, is the dividing line between the ancient and modern, for it was at that battle that fire-arms are said to have been introduced. It is true that gunpowder had been used before; but it is claimed that the matchlock first made its appearance at this contest. It is not to be inferred that armor at once disappeared after this fight, or that fire-arms came into immediate use. It was a long time before small arms and artillery assumed a commanding prominence.

According to some authorities, cannons were employed as early as 1338, at Cambray, which were used, not for the launching of balls, but what is known as quarrels—a projectile with a square head, and which had hitherto been used with a weapon known as the arblast. In the next year, cannons were used at the siege of Algesiras; and after this date their use steadily increased. "Cotemporary historians make mention of this novelty in warfare in a manner which prove them to have regarded it simply as a curiosity of no great value or importance—a proof that the cannon, at its first appearance on the field, not only did not produce any great effect, but also that it altogether failed to presage its

own subsequent career. This is a circumstance which explains itself. The original cannon, of very small size, which discharged darts or small stone balls, at most of three pounds in weight, was looked upon as neither more nor less than a substitute for the siege-arblast, or as a fresh engine of the same class, more noisy indeed than its predecessors, but not more calculated to do mischief. The many tales which have been told of the overwhelming terror caused by cannon on their first appearance have been proved to be worthless fictions of later age." *

It is worthy of note that among the first cannon made, the breech-loader occupied a conspicuous place, so that what has been esteemed the triumph of ingenious invention, in late days, is something which was attempted, and carried out, after a fashion, hundreds of years ago. According to Lacombe, the French writer just quoted from, the earliest cannon were made of hammered iron, and were tubes which were open from end to end, the whole being strengthened by rings. A shorter tube, having a bore of the same size, and closed at one end, contained the powder and the projectile; and this was placed with its open end to the longer tube, and held into place by a series of wedges. The most modern of breech-loaders is no more of a breech-loader than were these crude instruments; the difference is in the manner of applying the principle.

The age went in a bound from the small cannon which were first introduced to those of very extraordinary dimensions. Towards the end of the fourteenth century cannon were constructed which threw balls of stone weighing as many as two hundred pounds. These were known as bombardes; but they proved of little

* *Arms and Armor.* M. P. Lacombe.

value. So dangerous were the cannon of that period that they were not fired from the vent, or touch-hole; this was filled with fine powder, then a train of more slowly-burning powder was laid to a safe distance. While this was eating its way, after being ignited, to the cannon, the gunners had opportunity to gain some secure cover until after the explosion of the piece. One of the first improvements in use of artillery was in the projectile. The stone balls were hooped with bands of iron from which their battering qualities were very materially increased; the next improvement was in the casting of cannon of bronze.

Up to the middle of the fourteenth century, the cannon were taken into position by being dragged on blocks, with the result that when it was once in position there was no change in its range. Every effort was made to prevent recoil in the guns; consequently they were so wedged and braced, that once in place there was no such thing as varying the direction of the projectile. After the first shot was fired it was only necessary for the attacked party to move a little to one side or the other to escape anything in the nature of damage. It was after they had been in use for almost or quite a century that they were mounted on carriage wheels. It was only at this late period that a means was discovered for elevating and depressing the gun; the two improvements vastly increasing its value. A still further advance was made in 1483, when the first iron balls were cast; but at first they were made so large that they burst the cannon; this was corrected by the use of smaller ones; and then it was that the cannon of that period began to have some of the value which is possessed by those of the present day.

There is some conflict of authority as to when the mortar came into existence. It is said that one was

used in the siege of Naples in 1435; and that it was first made in England in 1543. Lacombe says that the mortar is a German invention, and was brought out first in the last half of the sixteenth century. In its construction, a mortar may be described as a short cannon with a very large bore, and which is used for the firing of shells. Knight speaks of one which was constructed by Mallet, and tested at Woolwich, England, in 1857, where it was charged with seventy pounds of powder, and which threw a shell weighing two thousand, five hundred pounds, one and one-half miles horizontally, and three-fourths of a mile in the air. Mortars are used for throwing their missiles high in the air, so that they may reach over and within fortifications, and then by the bursting of their shells to effect their damage. By this agency, men are kept under cover, and prevented from being as active as they otherwise would be.

Parenthetically, it may be remarked that during the late civil war, the city of Vicksburg, on the Mississippi, was kept for weeks under an incessant fire from mortar-boats, throwing shells weighing two hundred pounds; and yet the city was never fired, many of the inmates remained in their houses all during the bombardment; and that the loss of life and property was very small. In that instance, the result was in no sense adequate to the cost of the bombardment.

In 1798, an account was written of the island of Malta, in which occurs the following: "The rocks here are not only scarped into fortifications, but likewise into fire-engines or artillery to defend these fortifications; being hollowed out in many places in the form of immense mortars. These mortars they fill with cantars of cannon-balls, shells, stones, and other deadly materials; and if any enemy's ship should approach with design to land, they fire the whole into the air. The

effect of this tremendous invention must be very great, as it will produce a shower for two hundred or three hundred yards around, and would make great havoc among a debarkation of boats. A cantar is about one hundred pounds weight; and at the mouths of some of these mortars are six feet wide, they will throw according to calculation, one hundred cantars each." *

The important improvement of rifling the bores of cannon was not put in practical use till about 1854. There had been experiments made in this direction; but nothing came of them till about 1855, when the French government, having been taught by the experience of Sebastopol that smooth-bores were of but small comparative value, produced some rifled brass pieces. Col. Treuille de Beaulieu was the one who did the work, and who based his attempt on what had been discovered by early inventors, and by what he could evolve in the shape of improvements from his own inventive faculties. The first use of rifled cannon was in the Italian campaign of the late Napoleon, and in which they accomplished most wonderful results. At once every nation in Europe applied itself to the production of rifled cannon, and in which, at this date, England occupies with Prussia, a leading position.

It is scarcely necessary to follow up the various stages of advances in artillery till the present time. It may be stated that with all the improvements which have been made within the last twenty-five years, cannon are yet in a transition state; and that, wonderful as is what has occurred within that time, improvements not less wonderful may be looked for within the next quarter of a century.

There are various guns before the public which are

* An Account prepared for Napoleon.

renowned for their peculiarities, and their value for siege and field purposes. Among these are the Whitworth, Armstrong, Krupp, Rodman, Parrott, the late eighty-one-ton muzzle-loading gun turned out from Woolwich Arsenal, England, and possibly still others. The Armstrong guns are both muzzle and breech-loading. They are the largest guns made, some in use in the Italian navy being of one hundred tons, or nineteen tons heavier than the latest gun in use by the British navy. It is made of a barrel of solid steel, and over this are shrunk wrought-iron tubes. The Whitworth is made of a species of steel, the smaller ones being forged solid, while the larger ones are "built up" with coils which are forced on by hydraulic pressure. A peculiarity of the projectiles of the Whitworth gun is that they are very long. Those intended to be used against armor are made of steel, with flat heads, so that they will not glance off when striking a metal plate. This class of projectiles have no fuse when used as shells, the firing of the charge taking place from the heat generated by the impact of the steel with the metal plate against which it is fired.

The Krupp guns are among the very best, if not the best, constructed in modern times. They are made of cast steel, "composed of puddled steel, and pure wrought iron, melted in crucibles, and run into large ingots, which are worked under powerful steam hammers." The success, or rather the superiority of the Krupp guns over the artillery in use by the French, was shown during the Franco-Prussian war, when they played a most important part in the many victories which the Prussians obtained over their enemy

Alfred Krupp was born in Essen, in Dusseldorf, in 1812. His father was a locksmith and a worker in steel; a man with a good deal of inventive genius; but who seems to have been unlucky in his efforts at improvements,

ARMSTRONG ONE HUNDRED TON GUN.

one of which was an attempt to improve the quality of the steel with which he made his instruments. He died at forty, leaving all his business to his son, then only a lad of fifteen. At that time, Essen was a place of some eighteen thousand inhabitants; now the city of Essen has nearly one hundred thousand, all of which is due wholly to the genius of the inventor, Alfred Krupp.

He gave his attention to the casting of steel, and the manufacture of articles from that metal. He first attracted attention outside his own immediate surroundings by the exhibition in London of a solid block of his steel which weighed two and a quarter tons; in 1862, he sent a block of the same material which weighed twenty-five tons; and in 1867, he sent a block to the Paris Exposition which weighed forty tons; and if he could conveniently transport it, he could now exhibit one anywhere which weighs over two hundred tons.

He first conceived the idea of casting a cannon in steel in 1847. He had some practical difficulties at first, but in 1856 he produced breech-loaders of steel, cast in a single piece. In 1867, he exhibited the parent of monster guns, in a cannon which he exhibited at the Paris Exposition, which threw a projectile weighing a thousand pounds, and exploded a charge of one hundred pounds of powder. This is far from being large by comparison, at the present time. The eighty-one-ton gun uses some three hundred pounds of powder, and throws a projectile which weighs very nearly a ton.

Krupp's works at Essen are the largest in the world. He has a city of his own; his employés are the population of a metropolis, numbering many thousands. The number of cannon which he has cast is a very large one, being probably not less than ten thousand. Some ten years ago, his works at Essen included one thousand one hundred smelting and other furnaces, two hundred and

seventy-five coke ovens, two hundred and sixty-four smiths' forges, three hundred steam-boilers, seventy-one steam-hammers, two hundred and eighty-six steam-engines with an aggregate of ten thousand horse-power, one thousand and fifty-six machine tools, a chemical laboratory, and photographic, lithographic, and printing and book-binding establishments.

The inventor of the Whitworth gun has also a history not without some features of interest. Joseph, afterwards Sir Joseph Whitworth, was born in Stockport, England, in 1803. He was a mechanic from the outset, an inventor at an early age, and a man of accomplishments in mechanical and engineering science. His first inventions were in the construction of planing and tool machines, which were brought out in 1851. In 1854, he designed a cannon with a hexagonal bore, and the projectile before alluded to, and later, he applied the same principles to the construction of the breech-loading cannon which bears his name. He has been not only a mechanic, an inventor, and an engineer, but a writer, having published much on mechanical and kindred subjects. He was made a baronet in 1869; he was the English commmissioner to the International Exhibition held in New York in 1853.

Fraser, who constructed the thirty-five-ton gun for the English, is the one who also constructed the eighty-one-ton gun, at Woolwich, and it is this gun which is on the Inflexible, the latest and most formidable product of armored vessels in the British navy. It is not long since the seven-ton gun was considered the very limit of the construction of large guns; this was soon followed by the thirty-five and the eighty-one-ton guns. The writer, during a late visit to Woolwich, to inspect the manufacture of an eighty-one-ton gun, was assured by Mr. Fraser that he had drawn designs for a one hundred

and twenty-ton cannon, that he was entirely satisfied as to his ability to construct, but that, as yet, the government did not feel willing to undertake the labor. The length of the eighty-one-ton gun is twenty-seven feet, the diameter of the bore sixteen inches, and the projectile, as already said, nearly one ton in weight, the charge of powder being one-third the weight of the missile.

GATLING GUN MOUNTED ON TRIPOD.

One of the most important of the machines in use for purposes of war is that known as the mitrailleuse. That in use in the United States is known as the Gatling gun, in which there is a series of barrels which

revolve, on the turning of a crank, and which, as they revolve are charged, fired, and the empty cartridges removed. Not less than some twelve hundred shots a minute* can be fired by this machine, and with great accuracy. The gun is capable of delivering high-angle or mortar fire, so as to drop the bullets, with deadly effect on men behind intrenched positions, at all distances, from two hundred to three thousand five hundred yards. Tables of elevations and distances have been established, to obtain with certainty the above results. Experiments prove that the bullets so discharged come down in a nearly perpendicular line, and with sufficient force to penetrate from two to three inches of timber. It is the invention of J. R. Gatling, of Indianapolis; and is now in use in most of the countries of Europe except France, which has a machine-gun of its own invention. The French machine is one in which the cartridges, instead of being fed through a hopper, as in the case of the Gatlings, has charging blocks, somewhat the same as the Taylor gun, the invention of a Mr. Taylor, of Knoxville, Tennessee. Both these machines are of comparatively late invention, and in the case of this country, have not been used in any great battle.

There could be much more said upon the subject of the kinds of cannon in use, as their number is legion. Each of the many kinds has peculiarities of its own, as to manner of rifling, material of which the gun is composed, size of projectile, the appliance by which the projectile is made to "take" the grooves of the gun so as to admit of no windage, and to secure the rotating movement; but, however interesting all this would be, it is not within the limits of this volume, and must be passed to admit a continuation of the history of small arms.

* So claimed by the inventor.

The first weapon used as a small-arm, that is, which was carried, and discharged by the hand of the soldier, was no more than a small cannon fastened at

GATLING GUN WITH IMPROVED FEED.

the end of a stick. The first small-arm may therefore be properly termed a hand-cannon. This kind of a weapon is fairly believed to have been in use in the

latter part of the fourteenth century. The soldier carried something with which to touch off the weapon; and, except in size, it was in no essential respect different from an ordinary cannon either in construction, or in using when in action.

In the fifteenth century, from such evidence as can be obtained from the museums of antiquities, and from other sources, it is to be inferred that there were three kinds of this original small-arm, or culverin, as it is called, in existence. One of these was a small cannon placed on a stake, and there fastened by bridles of iron, the cannon being made of wrought iron; it employed two men, one of whom loaded and aimed it, and the other discharged it. The second was like the other, save that it was continued at the breech with a wooden stock; and the third was a culverin which was carried by cavalry. The last-named is much shorter than the others; it had its breech continued by an iron stock, was supported on the pommel of the saddle by a small fork. Not less than six thousand of this class of culverin were in use in the battle of Morat. In the first half of the sixteenth century, the arquebuse was invented in Spain. In this, the barrel is much longer than in the culverin, and it had an attachment for firing the priming.*

The arquebuse was very near the flint-lock musket which is within the memories of men not yet old. The vent was bored in the side instead of the top of the barrel; under this vent there was placed a little pan to hold the priming; and so far, it was exactly like the flint-lock. It had a cover which closed over the priming when the gun was not to be used. Behind the pan, there was a species of cock, with a pair of nippers at its

* *Arms and Armor.* M. P. Lacombe.

end; in this was inserted the fuse, or match. When the gun was to be fired, the pan was opened, the fuse was thrown forward and downward till it touched the priming, and thus ignited it.

In about 1530, the musket was introduced into Italy, having probably been there first made; it differed from the arquebuse in nothing save that it was longer and heavier. It was so heavy that when aim was taken and the gun fired, there was a forked stick provided in which it rested. It was known as the falcon, and the falconet. The caliver, the fusil, the carabine, are all simply lighter forms of the musket; the blunderbuss (thunderbuss) is a modification of the musket, having a shorter barrel and a larger bore; the musketoon is another lighter form of the musket; the very small arquebuse, or musket gave rise to the pistol, for the reason that its bore corresponded to the diameter of a coin named pistole; and between the arquebuse and the pistol came the petronel.

The Germans have the credit, according to the French writers, of having invented the wheel-lock. In this machine, the pan held the priming as in the case of the match-lock; a piece of flint was fastened just over the powder in the pan; there was a wheel with a fluted edge which touched the flint, and which, being made to revolve, by pulling the trigger, struck sparks from the flint which fell into the powder in the pan and ignited it. The wheel-lock continued in use till about 1630, when the Spaniards discovered and introduced to the world the flint-lock, in which the pan remains as in the match-lock, and the flint, held between the nippers of the cock—as was the lighted fuse in the match-lock—was released by the pulling of the trigger, and forced forward by a spring against the cover of the pan, opening it with the blow, and in the opening emitting sparks which fell on the priming. At the first, this flint-lock

did not meet with very great favor, and did not succeed in displacing the match-lock and wheel-lock from the field. From the beginning of the eighteenth century well into the nineteenth, the flint-lock held its own.

One of the greatest improvements which the small-arm encountered was in 1803, when the percussion cap was invented. Here again is a case which demonstrates the ingenuity, and the versatility of clergymen, for the invention of this great improvement is due to Rev. Alexander Forsythe, a Scotchman, who at the time of his invention, was living at Belhelvie, England. In this invention the pan was replaced by a tube, ending in a small truncated cone, on which was placed a small metal cap containing some fulminate; this was struck by the descending hammer, which was simply the old match-holder in a solid form. The blow exploded the fulminate, which ignited the powder shaken into the tube from the charge in the gun. This arquebuse with the percussion lock held its place for half a century; it assisted in settling all the great battles of the first sixty years of the present century. Within the last twenty years there may have been more improvements in small arms, than in all the prior five hundred years of their existence.

The smooth-bore musket, with the percussion lock, invented in 1803, held its own until after the war in the Crimea. In the civil war, in this country, although the government had adopted a rifled muzzle-loader, there were tens of thousands of the old, smooth-bore percussion locks issued to the troops. Nor was this clumsy mass of iron, weighing some fourteen pounds, without its ardent supporters. The writer recalls a conversation held with General (then Major) Sturgis, in which he vehemently defended the smooth-bore against the rifled guns being sparingly issued by the government. "You

don't want any accuracy in firing," said that officer. "All you have to do is to fire in the direction of the enemy, and if you miss one man you hit another." General Sturgis was not alone in this opinion. The first Napoleon had an opportunity to use a rifled weapon, but he preferred the ancient smooth-bore with the flintlock. The same is true of the Duke of Wellington.

The history of the musket in use in England up to the Crimean war is a curious one. In sporting guns, vast improvements had obtained; but "Brown Bess" for the use of the soldiers remained unchanged. It is admitted by a writer that the English government began to have some suspicion that "Brown Bess" was not all that a gun might be. "Prior to 1830 some perception of the superiority of the rifle had begun to be felt in Great Britain, after its efficiency had been witnessed in the hands of the Americans whose marksmen were indebted to its skillful use for their advantages over ourselves, as well as for subsequent successes in their expeditions against the Mexicans." Some statistics as to what could be done by this musket which, for so many years, held its place as the principal arm of the infantry of all the nations, are very curious. It was claimed that it had an effective range of two hundred yards; the rule was that the soldier was to reserve his fire until he saw the whites of the eyes of the enemy, and yet, even at this distance it is said that a soldier had to fire the weight of his body in lead before he could succeed in bringing down one of the foe. At the battle of Salamanca, there were three million five hundred thousand cartridges, and six thousand balls fired, and several charges made both by the foot and cavalry, and yet there were only eight thousand men killed and wounded, from which comes the inference that only one shot in four hundred and thirty-seven took effect. During the Caffre war, in

a single engagement there were eighty thousand cartridges fired, resulting in the knocking over of twenty-five of the enemy. A square of British infantry, at Waterloo, fired at short range on a body of Erench cavalry which was charging, and only emptied two or three saddles. In another case, a fire of a square on cavalry, at thirty paces, only brought down three men. The French troops during the Crimean war fired some twenty-five million cartridges, of which not more than one in two thousand took effect. *

The results of some experiments made with the musket in 1833, are given by the *Review* of Edinburgh. The first target employed was three feet wide, and eleven feet six inches high, which was struck by about three-fourths of the balls at one hundred and fifty yards, fired with full charges—with reduced charges only above one-half hit. Beyond this distance, the difficulty of hitting was so great that the width of the target had to be increased to six feet; and at two hundred and fifty yards, of ten shots fired with full charges, not one hit the target; at three hundred yards, shot after shot was fired without one hitting the object aimed at, or its whereabouts being ascertained. After various expedients in vain resorted to to hit such an object at such a range, the officers gave it up in despair; and proceeded to calculate a table of instruction for soldiers in firing with the musket, some of which will appear strange at the present day. The soldier was told in firing at a man, at six hundred yards, to fire one hundred and thirty feet above him! Another case is given in which an expert marksman was provided with a regulation musket, and placed in position to fire at a target eighteen feet square at a distance of three hundred yards, with the result

* *Spectator, Edinburgh Review*, etc.

that he could not hit even this target more than once in twenty times. Even at two hundred yards he met with no greater success. *

It was with such a gun as this that the English fought all their great battles up to and inclusive of those in the Crimea. It was not till after the close of this long and costly war with the Russians that a change was effected. The reason why such results were obtained is said to be owing to the fact that the barrels were defectively bored; that the bullet did not fit; that when fired, it bounded from side to side in the barrel, and once launched in the air, it was liable to go in any direction save that which was desired.

While it is very strange that the use of the rifle did not come into general use among the nations till within the last quarter of a century, there were reasons why it was not universally adopted when first discovered. It was really invented some centuries ago, it being supposed that rifling the bore of an arm was invented in the fifteenth century by Gaspard Zöllner, of Vienna. This original rifling was simply the cutting of some grooves which ran parallel to the axis of the bore; the later and present form being one in which the grooves are spiral; that is, they start from the bottom of the bore, and twist as they progress toward the muzzle. The date of the spiral grooving is not known to a certainty, although there are some authorities which accredit it to Augustin Kutter, of Nuremberg, in about the year 1600.

For a time, rifled small-arms were in use. In 1674, the elector of Brandenburg, the ancestor of the present emperor of Germany, had riflemen distributed among his regiments. Frederick the Great had a regiment of riflemen in his army. This was in 1740; but before him,

* *Edinburgh Review*, April, 1859.

in 1645, there were three regiments of riflemen organized in Bavaria; and in 1689, the French had some of their soldiers armed with the improved gun. In the latter part of the eighteenth century, the Swiss and Austrians placed much reliance on the rifled weapon. In 1794, the British, having learned something from the reception given them during the American revolt by the American riflemen, adopted the rifle as a part of their armament. But in all these cases there were many difficulties in the use of the rifle; it had no bayonet; it was very slow work to load it; the bore easily became fouled, often requiring that the bullet should be hammered home with a mallet; and the result of it all was that this implement did not gain in favor.

It was not till about 1826 that rifling began to display some of its real value. Up to this period, there had been no means used to make the ball "take" the twist to any considerable extent. At this date, Lieut. Delvigne, attached to the French artillery, invented a rifle in which there was a chamber at the bottom of the bore, less in diameter than the bore, and less than that of the ball. The chamber held the charge, the ball was dropped in and rested on the top of the chamber, and was then rammed until it was driven into the grooves, and in this way, an effective twist was secured. Although this plan produced a considerable increase in range and accuracy, it will be readily seen that the interference with the sphericity of the ball resulted in a shape which presented much resistance to the air, and that in consequence, no great range was possible. The next invention for the purpose of making the ball "take" the grooves was that of Col. Thouvenin, who inserted at the bottom of the bore a small steel rod, one-fourth of an inch in diameter, and whose height was equal to that of the charge of powder. When the ball was dropped in, it was caught

on the end of this steel rod, and was there held until it was rammed enough to force the sides of the ball into the grooves. This improvement is said to have been a very important one, as it enabled good practice at five hundred yards.

It was in 1845 that one of the greatest improvements in the shape of the projectile, and in getting the benefit of the rifling was invented by Capt. Minié of the French service. It was in the shape of an elongated bullet, such as are now in use in arms of all description, whether cannon or small-arms. In 1849, he improved his first bullet, and gave us that which is still in extensive use. It was cone-shaped, and had at the bottom a little recess, also cone-shaped, and in which was an iron cup, something like a conical thimble. The lower edges of the ball being thus made thin by the hollowing out, when the piece was discharged, the thimble was forced forward, driving outward the thinned edges of the ball, and into the grooves of the bore. The invention of Capt. Minié revolutionized projectiles. But it was not till 1861, that a revolution took place in the use of guns which loaded at the muzzle.

As was said in another place, one of the earliest of the improvements connected with fire-arms was the introduction of breech-loaders. But at the outset, they were clumsy, and, like the cannon to which they were attached, they were about as dangerous to friend as foe. The earliest patent on record is that of Abraham Hall, an Englishman, in 1664, which recites that the arm is made breech-loading by "a hole at the upper end of the breech to receive the charge, which hole is opened or stopped by a piece of iron or steel which lies alongside of the piece, and movable by a ready and easy motion."

The first breech-loader in this country was invented in 1811, by John N. Hall, of Yarmouth, Massachusetts.

This was adopted by the government, and a large quantity of them was made and used on the frontiers; and carbines, made in the same way, were in use by the mounted men during the war with Mexico. It was arranged so as to be used with both the flint, and percussion lock. But it was not till after the war of 1861–6 that there was much effort made in the invention of breech-loaders in this country, although prior to the war there were several in existence, among which was Sharpe's, Burnside's, Maynard's, Spencer's, and Merrill's. It will surprise most people to learn that since January, 1837, there have been patented in this country perhaps not less than two thousand different forms of breech-loading fire-arms, in which the difference is, in the main, in the manner of inserting the cartridge. But few of these have ever been heard of outside of the patent office. For a time, the Sharpe gun, which was patented in about 1850, was a very noted fire-arm, more especially in its connection with the political excitement concerning Kansas; and at which time the gift of a "Bible and a Sharpe's rifle" was considered the thing for a man with anti-slavery views who was about to move from the east to that state. Among others which are more or less known are the Henry, Remington, Ballard, Berdan, Peabody, Winchester, Springfield (in use by the United States government), Spencer, and others.

It should be understood that of the large number patented in this country, a good many were by foreign inventors, such as Chassepot, the inventor of the national small-arm of the French. The various small-arms in use by the various countries are as follows: France, the Chassepot; Belgium, the Albani; Holland, the Snider, (an American invention); Turkey, the Remington and Winchester; Austria, the Wanzl; Sweden, the Hagstrom; Russia, the Laidley, and the Berdan; Switzerland,

the Winchester; Portugal, the Westley-Richards; Prussia, the Zündnadelgewähr (the famous needle-gun) and the Mauser rifle; England, the Martini-Henry, or the Snider improvement on the Enfield; and the United States, the Springfield, which is a converted muzzle-loader. All of these are excellent guns, and are as much superior to the fire-arms in use a quarter of a century ago, as the steam-car is superior to the ox-cart.

One of the most noted of these is the needle-gun in use by the Prussian army, and which made the king of Prussia the emperor of Germany. It was the invention of a mechanic named Johann Nikolaus von Dreyse, who was born in Sömmerda, Prussia, in November, 1787, and who died in December, 1867. He was the son of a locksmith, whose trade he learned, and worked at it till 1809, when he went to Paris, and was there employed in a rifle factory till 1814. In 1824 he received a patent for the invention of percussion caps, and a year later, he obtained another patent for a steam-engine worked by a generator instead of boiler. In 1827 he obtained a patent on a muzzle-loading, and in 1836, on a breech-loading gun. The invention and construction of these guns were carried on under the patronage of the Prussian government. In 1840, his breech-loader was adopted by the Prussian government, for whom he manufactured up to 1863, over three hundred thousand of his new pieces. This gun is a very effective weapon, being able to afford good target practice at from twelve to fifteen hundred yards. Its peculiarity is that the fulminate which fires the cartridge is placed between the powder and the bullet; when fired, a steel needle is driven through the cartridge until it strikes and explodes the fulminate. It is thought that, by this process, all the powder is discharged and utilized, which may not happen when exploded from the rear.

Another very notable arm is the Chassepot of the French, and which is not only a less clumsy weapon in appearance than the Prussian needle-gun, but is claimed by its advocates to be a much more effective weapon. Its inventor, Antoine Alphonse Chassepot, gave his name to the weapon. He was born in 1833, and like his father, worked in a manufactory for the construction of arms. His invention cost him many years of study; but he completed it in time to permit its adoption after the Prussian victories over the Austrians, and which demonstrated the necessity of having some weapon to compete with the Prussian needle-gun. It differs from the Prussian gun in the location of the fulminate, which in the chassepot, is located at the rear of the cartridge instead of at the rear of the bullet.

All the breech-loaders in use have the metallic cartridge, and those which have been adopted as a national arm, have a range of about a thousand yards, which is at least eight hundred yards more than was the range of the musket in general use twenty-five years ago. The guns which have a range above one thousand yards are the Martini-Henry, of Great Britain; the Beaumont, of Holland; the Chassepot, of France; and the Mauser, said to be in use in North Germany. During the Russo-Turkish war, a correspondent of one of the London papers, related that while he was sitting among some Russians, a bullet, fired from the Turkish works, struck close to them in a bank of clay. Curiosity led them to dig out the missile, which was found to have imbedded itself to the depth of sixteen inches in the bank. The Turks were armed with the Remington and Winchester rifles; the distance from the point where the gun was fired to the place where the bullet struck, was just one mile, as was afterwards ascertained by measurement.

Pistols came into use before the close of the sixteenth century. They were, however, of little value as a fire-arm until about 1830, when Delvigne, already referred to, invented a rifled pistol with a single barrel and a percussion lock, which is said to have had an effective range of two hundred yards (which is very extraordinary), and to have been much more efficient than the muskets then in use. It was not till 1836 that the splendid modern pistol, known as the revolver, came into existence.

In that year, Col. Samuel Colt, of Hartford, Conn., invented the revolving pistol which bears his name, and which is the model from which all modern revolvers have been constructed. It is not claimed that the principles involved in a fire-arm, which has several chambers revolving at the breach are original conceptions of Col. Colt; but to him is due the reducing of these principles to practice, and giving them the quality of utility. There is no lack of attempts to deny him credit in this respect on the ground that there are models of revolving fire-arms to be found in various museums of antiquities in the old world. It is true that there are several of these to be found. In the Tower of London, there is a match-lock of the fifteenth century which has a revolving breech with four chambers, and which greatly resembles the modern revolver. It is so arranged that the chambers may be turned by hand so as to bring the loaded one in line with the barrel of the gun. There is a single cock, or hammer, carrying the match, and on each of the barrels is a priming-pan, the cover of which was pushed back by the thumb when it was brought into position to be discharged. There is also another revolver in the same building which is an ancient arquebuse, with six chambers. Like the other, the breech is rotated by hand, and the main difference

between them is that there is but one priming-pan for all the chambers instead of one for each chamber. Unlike the other, it is a wheel-lock.

Another arquebuse in the Tower of London, has six chambers, in a revolving breech, in which the chambers are revolved automatically, and the discharge effected by a flint-lock, and a single priming-pan. There are still others with the revolving breech, several of which date back to the fifteenth century, and one which is the invention of a man named Elisha Collier, patented in the United States in 1818. In the last-named, there are five chambers which are turned by hand, and in the hammer there is a magazine of priming placed in the stock.

Despite all these facts as to the existence of these various revolving fire-arms, the credit of Colt is none the less for his invention. The ancient revolvers are rusting in the tower of London, and in other antiquarian collections; the revolver of Colt, and all other modern revolvers of which his was the type, are realities, heard on every battle-field, and carried as a weapon for offence and defence in every part of the civilized globe.

The history of Colt's life illustrates what has already so often been demonstrated in this volume, that a man, to win fame and fortune, does not need the aid of wealth or powerful friends. Each of Napoleon's soldiers carried the baton of a marshal in his knapsack; so every man carries within himself the possibilities of the greatest achievements and the hightest rewards. He was born in Hartford, Conn., in July, 1814, and died there January 10, 1862. His father was a silk and woolen manufacturer, into whose employ the son entered when he was but ten years of age, preferring this to going to school; being soon after sent to school, he ran away, and shipped on a vessel bound for the East Indies. It

is said that while on the voyage, he made a model in wood of a revolving pistol which was the same in principle as the celebrated one which he gave to the world. This model is yet in existence.

Upon his return from the Indies, he studied the chemistry of dyeing, after which he traveled through this country and Canada, giving lectures on the subjects which he had just mastered. In 1835, he visited England and France, and took out patents for a revolving fire-arm, and the next year took out patents for the same in the United States. In a subsequent visit to Europe, he saw for the first time the specimens of ancient revolving fire-arms, and in order to free himself from any suspicion of having borrowed his conceptions from these weapons, he prepared a very elaborate paper on the subject of ancient revolvers, and his own invention, which he read before the Institution of Civil Engineers of England.

It was a long and wearisome labor for him to secure any substantial returns for his investments in the time, money, and effort which his invention had cost him. He started a company for the manufacture of the new weapon, but it became insolvent. It was not till the great gold excitement in California broke out that there began to be a steady demand for his revolver; and then it became so great that he found it impossible to supply all the weapons that were called for. The demand for them began to come from all parts of the world; another company was started; works were constructed which cost him some three million dollars; and now these works are turning out about one thousand of the Colt revolver each day.

It may be added that all the machinery used in the manufacture of the Colt's arms was made on the ground; and that it was from his shops that they were furnished

to the British government, and to that of Russia the machines with which they carry on the manufacture of revolving weapons. Colt also invented a submarine battery which has taken high rank among military men; and a method of insulating submarine cables which met with success. He was the recipient of medals, decorations, and various other evidences of favor from most of the governments of Europe and from many of the Asiatic sovereigns.

Very much more might be said on the subject of fire-arms, and other appliances for offence and defence; but, in reality, the subject is one which is practically unlimited. The subjects of the various projectiles in use; of metallic cartridges; of shells, case, cannister and schrapnel; these alone would furnish ample material for a book of no mean size. Then, under the head of appliances for offence and defence, would come armored ships, their armament; the innumerable torpedo vessels and their missiles; all of which and many others would furnish matter of intense interest, but which cannot be entered on in detail in a volume of the dimensions of the present one.

It will be conceded that the vast and numerous improvements which have been made within a few years in guns will have a most beneficial result. All these improvements have the effect to render war too expensive in the matter of life for the idle indulgence of any ruler. Monarchs can no longer declare war from a mere whim, for purposes of robbery, for the smile of a woman, as has been so often the case in the history of the nations. The arms of precision, which project their deadly missiles for a thousand yards, have had a subduing effect on mere wars of conquest. It was the rifled guns of the Boers, their improved bullets, and the faultless marksmanship of these loutish farmers which gave

them such an advantage over the forces of Great Britain, that they were conceded their liberty. Great wars are infrequent just now, for the reason that they are so deadly; it is only the gravest of causes which will force any nation to invoke their hurricanes of destruction.

The time is not distant when war will be still more deadly, and the nations proportionately unwilling to breast its horrors. The invention of new explosives, in the shape of nitro-glycerine, and others that are in use, opens up a possibility, even a probability, that war may be soon rendered so costly that there will be none who will dare venture upon it. Torpedoes, charged with this tremendous energy, may make armored ships useless, and the encounter of ships, and armies the equivalent of mutual annihilation. Balloons carrying bombs of this new agent may rise above cities, and in a few moments inflict a destruction in property which will be so vast that it will be beyond remedy. Instead of enormous standing armies, vast accumulation of expensive material, the war-powers of the future may consist of a small supply of nitro-glycerine and a few light, ærial vehicles for its employment. When this shall come to pass, the nations will have arrived at permanent peace.

CHAPTER XXII.

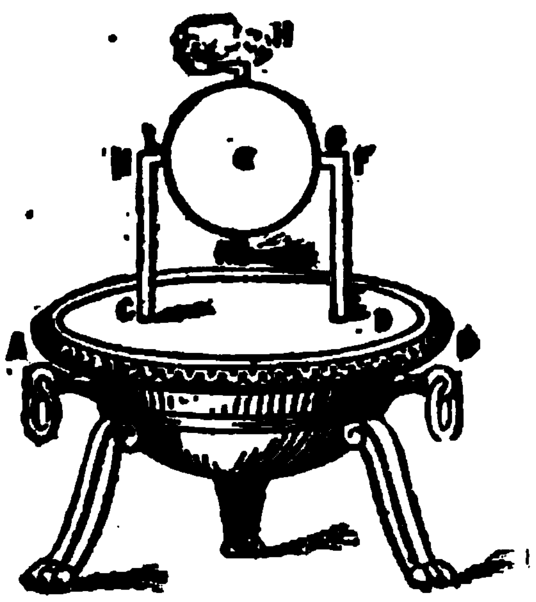
STEAM AND ITS APPLICATIONS.

THE discovery of steam, or the invention of a steam-engine, that is, an engine for the employment of the forces of steam, belongs exclusively to no man, and scarcely to any age. As far back as one can scan the past, steam was known, and some appliance for its utilization in one form or another.

It is a something which has been developed slowly, and which has reached its present development by a gradual series of advances whose beginning is lost in the remoter ages. Here and there, men have accelerated its progress beyond its average speed; such men as Papin, Newcomen, Watts, and others; but all of them were no more than improvers. They took the powerful gas, and changed the form of its application so as to produce better effects; they took machinery which was vitalized with power by steam, and altered it so that its purpose was widened, and its utility was increased in new directions. But none of them discovered steam, or invented the steam-engine. The Ælopile of Hero, or the device of the same for the opening of the doors of a temple, are just as much steam-engines as the proudest of modern locomotives.

The writings of Hero, some 200 years before Christ, describe hydraulic inventions which were made before his time, and such as were made by himself. Among these

are many machines which were operated by steam, and still others which were moved by the expansion of heated air. In his works, several "steam-boilers are described, usually simple pipes or cylindrical vessels, the steam being generated in them by the fire on the altar, and thus forms a steam-blast." But it is to be observed that, so far as can be ascertained, while there are abundant evidences that steam was known long before Christ, its use was mainly in toys such as the Æolipile of Hero, and in operations connected with the administration of the



HERO'S ENGINE. (B. C. 200.)

pagan priests, designed to excite the wonder and fear of the masses, and lead them into the belief that the priests were possessed of supernatural powers.

From the time of Hero, 200 B. C., there is substantially nothing said of steam for more than a thousand years. Even at the end of this period, what is mentioned is in the nature of a very attenuated legend. There is said to have been a clock in the twelfth century, in Rheims, whose motor was air which was compressed by heated water. It was not till the sixteenth century that we began to get any definite information as to the knowledge of steam as a motor. A late modern writer* states

* Robt. A. Thurston.

that Hieronymus Cardan, of the middle of the sixteenth century, in his writings called attention to the power of steam, and the facility with which a vacuum can be obtained by its condensation. The same modern writer says that many traces are found in the history of the sixteenth century of some knowledge of the properties of steam, and some anticipation of the advantages to follow its application. He quotes from Matthesius, who, in 1571, described in one of his sermons, a "contrivance which may be termed a steam-engine," and sets forth the "tremendous results which may follow the volcanic action of a small quantity of confined vapor." About the same time, the Æolipile of Hero was made use of to turn the spit.

In 1569, Jacob Besson, at Orleans, published among many other things, a tract which, according to Thurston, "described very intelligently the generation of steam by the communication of heat to water, and its peculiar properties." In 1588, an Italian named Agostino Ramelli, born and educated at Rome, published a book in which he described many machines adapted to various ends, some of which have furnished the stock-in-trade of many later and so-called inventors. The Spaniards claim that as early as 1543, a Spanish naval officer, named Blasco de Garay, undertook to move a ship by paddle-wheels, from which they infer that the use of steam was known at that early period. This is inferred from the statement in the discovered account that a vessel of boiling water was a part of the appliances that was used in the attempt.

Giambattista della Porta, who was born in Naples in 1540, and who died at the same place in 1615, devoted his time to study. He published several works, such as *De Humana*, *Physiognomia*, and *Spiritali*, in the latter of which he describes how a column of water can be

raised by the production of a vacuum by the condensation of steam. Porta occupied a distinguished position; he knew too much for his age, and brought himself under the displeasure of the church from a belief that he was engaged in the practice of magic; which meant, in those days, knowing more than the law allowed. He improved the theories of optics, was the inventor of the camera obscura; and wrote voluminously of natural magic, secret writing, landscape gardening, chemistry, meteorology, etc. A rude engraving of his steam-apparatus was left in his works, in which there is a furnace on which is a boiler. A tube leads from the boiler into a tank, and terminates near the top of the tank. Another tube starts from near the bottom of the tank and passes out through the top into the open air. As the steam issues into the tank through the tube from the boiler below, it creates a pressure on the surface of the water, and thus forces it down, into, and up through the tube which leads into the open air.

In 1615, Salomon de Caus, a Frenchman, made a drawing of a plan of a machine which, while different in outline, is precisely the same as that of Porta, for the raising of water by the use of steam. In 1629, Giovanno Branca, an Italian, described a steam-engine in which he secured motion for machinery by having steam issue from a tube and strike against the vanes of a horizontal wheel. In 1630, a patent was granted to David Ramsay, of England, for several inventions, among which was one for raising water from pits by the use of fire; another to make any sort of mills "goe on standing waters by continual motion, without help of wind, water, or horse; to make boats, shippes, and barges to goe against strong wind and tide; to raise water from low places and mynes and coal pitts by a new waie never yet in use."* Several

* Thurston.

of these are unmistakably steam-engines. There were patents issued in England in 1632 and 1640 for machines to move ships against wind and tide.

Up to 1663, the use of steam had been mainly confined to the production of blasts for the smelting of ores, for turning spits, and other light work. That steam had been carried further than this is asserted, by the inventions of the famous Edward Somerset, better known as the second Marquis of Worcester. He is claimed by many to be the real and only inventor of the steam-engine; and to prove, and to refute this, a library of books has been written. It has even been asserted that such a man never had any existence; and yet there is no lack of a work by him named the *Century*, which was issued first in 1663, and which has several times been since republished. This title, *Century*, does not have reference to the space of time of a hundred years, but to one hundred inventions in it which he puts on record, and claims as his own.

These one hundred inventions are made up of those which refer to seals and watches, games, arithmetic and perspective, automata, ciphers, correspondence and signals, domestic affairs, mechanical appliances, naval and military affairs, hydraulics and the water-engine. Many of his inventions are very curious. He shows a system of short-hand in which the pen needs never be raised from the paper. Nos. 6 and 7 refer to a method of communicating between two persons, by day or night, as far as the eye can discover black from white, "without noise made or notice taken," and which may be practiced at the moment, without premeditation. No. 9 is "an engine, portable in one's pocket, which may be carried and fastened on the inside of the greatest ship, *tanquam aliud agens*, and at any appointed minute, though a week after, either day or night, it shall irrevocably sink

that ship." Is not here the ante-type of some "infernal machines" which have seen the light within the last ten years? It is within ten years that a German steamer was blown up by an infernal machine which had been placed on board, and which was arranged to explode by the agency of clock-work. The next invention foreshadows the torpedo, for it says: "A way from a mile off to dive and fasten a like engine to any ship, so as it may punctually work the same effect either for time or for execution." His next invention, No. 11, is a panacea for the poison of the last, for it is, "How to prevent and safeguard any ship from such attempt by day or night."

No. 13 is an invention for making such false decks to a ship as should kill and take prisoners as many as should board the ship, and without in any way interfering with the integrity of the decks, so that in half an hour they should all be replaced in their original position. No. 15 shows, "how to make a boat work itself against wind and tide, yea both without the help of man or beast; yet so that the wind or tide, though directly opposite, shall force the ship against itself; and in no point of compass but it shall be as effectual as if the wind were in the Pupp, or the stream actually with the course it is to steer, according to which the oars shall row, and necessary motions work and move towards the desired port or point of the compass." It is supposed that the machine here referred to is one in which paddles are driven by wind or water. That paddles were known at this period is proved by the fact that there is an engraving extant, of the first part of the sixteenth century, of large vessels with paddles which are worked by animal power. "The ancients had a way to drive their ships without oar or sail, so that they never could be wind-bound." *

* *Humane Industry.* 1661.

The sixteenth invention of Worcester was, "how to make a sea-castle or fortification cannon-proof, containing a thousand men, yet sailable at pleasure to defend a passage, or in an hour's time to divide itself into three ships as fit and trimmed to sail as before; and even whilst it is a fort or castle, they shall be unanimously steered, and effectually driven by an indifferent strong wind." The suggestion in this instance is not wholly original, as the plan of a ship which should be divisible into three or united as one, at pleasure, was often suggested by the early writers.

No. 18 is an "artificial fountain, to be turned like an hour-glass by a child, in the twinkling of an eye, yet holding great quantities of water, and of force sufficient to make snow, ice, and thunder, with the chirping of birds, and shewing of several shapes and effects usual to fountains of pleasure." No. 19 would be of great value if it could be introduced at the present day. It is a "little engine within a coach, whereby a child may stop it, and secure all persons in it, and the coachman himself, though the horses be ever so unruly and running in a full career; a child being sufficiently capable to unloose them in what posture soever they should have put themselves, turning never so short; for a child can do it in the twinkling of an eye." Something of the same sort has lately been made the subject of a patent in this country; it is an attachment which, by a motion of a lever, releases the horses from the carriage, and is so very simple that even a child can handle it.

No. 20 is a very non-understandable machine; and if it has ever been put in operation, the fact is not on record. It is "how to bring up water balancewise, so that a little weight or force as will turn a balance will be only needful, more than the weight of the water within the buckets, which counterpoise and empty themselves one

into the other, the uppermost yielding its water (how great a quantity soever it holds) at the same time the lowermost taketh it in, though it be an hundred fathom high."

No. 28 would be of the greatest advantage in modern days when the material for pontooning a stream, in war time especially, demands a large amount of transportation, and considerable time to lay it. See how simple is the invention of Worcester: "A bridge, portable in a cart with six horses, which in a few hours time may be placed over a river half a mile broad, whereon with much expedition may be transported horse, foot, and cannon." The following one may be found of use to military men: "A portable fortification able to contain five hundred fighting men, and in six hours time may be set up, and made cannon-proof, upon the side of a river, or a pass, with cannon mounted on it, and as complete as a regular fortification, with half-moons and counterscarps."

Another of his suggestions would be a capital thing if it could be put in use to-day: "How to compose an universal character methodical and easy to be written, yet intelligible in any language; so that if an Englishman write it in English, a French, Italian, Spaniard, Irish, Welshman, being scholars; yea, Grecian, or Hebritian shall as perfectly understand it in their own tongue, as if they were English, distinguishing the verbs from the nouns, the numbers, tenses, cases as properly expressed in their own language as it was written in English." No clue is given by the marquis as to how he would bring about this wonderful reform; for certainly, next to use of electricity, and that of steam, there could be nothing which would be of more universal benefit than this "universal character."

From 33 to 43, the "Century" is taken up with various ways of constructing alphabets. Among these

are a needle alphabet which is made by the manner in which the stitches are taken—an alphabet dependent on the manner in which a silk string is knotted; the same by the fringe of the gloves, by the stringing of a bracelet, the holes in the bottom of a sleeve, by a lantern, by the taste, the touch and the smell; all being for the purpose of carrying on a correspondence which can only be understood by those in the secret. The last of them is one which is: "how to vary all these, so that ten thousand may know them, and keep the understanding part from any but their correspondents." This is, perhaps, more ingenious rather than valuable. Cipher writing is very old. Long before even Worcester, the Neapolitan, Porta, who died in 1515, wrote a work * in which he gave no less than one hundred and eighty different methods of secret writing.*

No. 44 might be valuable as a curiosity in these days, but it has been supplanted by more effective weapons: "To make a key of a chamber, which to your sight hath its wards, rose-pipe but paper thick, and yet at pleasure in a minute of an hour shall become a perfect pistol, capable to shoot through a breast-plate commonly of carabine-proof, with prime, powder, and fire-lock, undiscoverable in a stranger's hand." The next possesses considerable utility. It is: "How to light a fire and a candle at what hour of the night one awaketh, without rising or putting one's hand out of the bed. And the same becomes to be a serviceable pistol at pleasure; yet by a stranger, not knowing the secret, seemeth but a dextrous tinder-box." It might not be very difficult to construct something of the kind, if one should have clock-work which when loosened, should strike a flint and ignite some tinder.

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* *De Occultis Literarium Notis.*

In his fiftieth invention the marquis attained something which would be of great utility could it come into general use. It is a "complete light, portable ladder, which taken out of one's pocket, may be by himself fastened an hundred foot high to get up by from the ground." Worcester was not alone in this class of invention, nor even original. In 1659, there was published the following from a very noted source: "It is possible to invent an engine of a little bulk, yet of great efficacy, either to the depressing or the elevating of the greatest weight; which would be of much consequence in several accidents; for hereby a man may ascend or descend any walls, delivering himself or his comrades from prison; and this engine is only three fingers high, and four broad."* Unfortunately neither of these inventors has left us any hints which will enable us to reconstruct the convenient and ingenious "engine" thus referred to.

The marquis gave a good deal of time to the improvements of fire-arms; No. 58, and several subsequent inventions have reference to rapid firing. The first of them is: "How to make a pistol to discharge a dozen times with one loading, and without so much as one new priming requisite, or to change it out of one hand into the other, or stop one's horse." The principle here involved is probably the same as that given in *Natural Magick* by Porta, in 1658, in which there is first put some powder, and then a ball in the gun, and on this some "dark clammy powder," then more powder and a bullet, alternating the charge and the "dark clammy" powder till the gun was filled. This "dark clammy" powder was probably something in the nature of saltpetre, which would burn slowly, and which as it burned

Discovery of the Miracles of Art, Nature and Magick.* **Friar Bacon.

down the barrel would, in turn, reach each charge of gunpowder, and discharge it. This is further proven by the fact that Porta says the ball must go in loosely, this being to allow the slow fire to fill the space about the ball, and, in this way, reach the powder below each bullet.

No. 64 is an invention, "tried and approved before the late King (of ever blessed memory) and an hundred Lords and Commons, in a Cannon of eight inches and a quarter, to shoot Bullets of sixty-four pounds weight, and twenty-four pounds of powder, twenty times in six minutes; so clear from danger, that after all were discharged, a Pound of Butter did not melt, being laid on the Cannon-britch, nor the green Oile discoloured that was first anointed it, and used between the Barrel thereof, and the engine, having never in it, nor within six foot, but one charge at a time." Nothing has been left to indicate the processes which the inventor used to secure such rapid results with no perceptible heating of the barrel. In these days an invention which would prevent the heating of gun-barrels would speedily enrich the inventor.

The next three are still war-like inventions. (1) "A way that one man in the Cabin may govern the whole side of Ship-musquets, to the number (if need required) of two or three thousand shots." (2) "A way that against several Avenues to a fort or a Castle, one man may charge fifty Cannons playing, and stopping when he pleaseth, though out of sight of the Cannon." (3) "A rare way likewise for musquettoons fastened to the Pummel of the Saddle, so that a Common Trooper cannot miss to charge them, with twenty or thirty Bullets at a time, even in a full career."

No. 68 of his inventions is the most important of all of them, and would make him famous had all the

others of his *Century* been unknown. In full, it is as follows:

"An admirable and most forcible way to drive up water by fire, not by drawing or sucking it upwards, for that must be as the Philosopher calleth it *Intra sphæram activitatis*, which is but at such a distance. But this way hath no Bounder, if the vessels be strong enough; for I have taken a piece of a whole cannon, whereof the end was burst, and filled it three-quarters full of water, stopping and scruing up the broken end; as also the Touch-hole; and making a constant fire under it, within twenty-four hours it burst, and made a great crack: so that having a way to make my vessels so that they are strengthened by the force within them, and the one to fill after the other. I have seen the water run like a constant fountaine-stream forty foot high; one vessel of water rarified by fire driveth up forty of cold water. And the man that tends the work is but to turn two cocks that one vessel of water being consumed, another begins to force and re-fill with cold water, and so successively, the fire being tended and kept constant, which the self-same person may likewise abundantly perform in the interim between the necessity of turning the said cocks."

In 1702, Thomas Savery made a publication of his invention for raising water by means of vacuums produced by the condensation of steam in a vessel, and alludes to it as "its first appearance in the world." In speaking of his invention in the same publication, he says: "A man that tends the work is but to turn two cocks, that one vessel of water being consumed, another begins to force and refill with cold water, and so successively, the fire being tended and kept constant, which the self-same person may likewise abundantly perform between the necessity of turning the said cocks." If

the reader will glance back over No. 68, which was published more than thirty years anterior to the so-called invention of Savery, he will see that not only is the machine referred to by Worcester the same as that of Savery, but that the latter, in the extracts given, uses substantially the same words. In other words, Savery took his ideas of the raising of water by the use of fire and water from Worcester, and even his language in order to describe it.*

There seems to be a very powerful weight of authorities against Savery as the inventor of the engine for the raising of water by the agency of steam. The one-hundredth invention of the Marquis of Worcester is a further affirmation of his invention of the "Water-commanding" engine. He describes it thus: "A water-work is by many years' experience and labor so advantageously by me contrived that a child's force bringeth up a hundred foot high an incredible quantity of water, even two foot diameter, so naturally, that the work will not be heard even in the next Room; and with

* Captain Savery having read the Marquis of Worcester's book, was the first to put in practice the raising of water by fire, which he proposed for the draining of mines. His engine is described in *Harris' Lexicon*, which being compared with the Marquis of Worcester's description, will easily appear to have been taken from him; though Captain Savery denied it, and the better to conceal the matter bought up all of the Marquis of Worcester's books that he could purchase in Paternoster Row and elsewhere, and burned them in the presence of the gentleman, his friend, who told me this. He (Savery) said that he found out the power of steam by chance, and invented the following story to persuade people to believe it, viz., that having drunk a flask of Florence at a tavern, and thrown the empty flask on the fire, he called for a basin of water to wash his hands, and perceiving that the little wine left in the flask had filled up the flask with steam, he took the flask by the neck, and plunged the mouth of it under the surface of the water in the basin, and the water of the basin was immediately driven up into the flask by the pressure of the air. *Course of Experimental Philosophy.* 1763. Dr. J. T. Desaguliers, F. R. S. and Chaplain to His Royal Highness, Frederick, late Prince of Wales, etc.

so great ease and geometrical symmetry, that though it work day and night from one end of the year to the other, it will not require forty shillings reparation to the whole engine nor hinder one day-work. And I may boldly call it the most stupendous work in the whole world; not only with little charge to drein all sorts of mines, and furnish cities with water, though never so high seated, as well as to keep them sweet, running through several streets, and so performing the work of scavengers, as well as furnishing the inhabitants with sufficient water for their private occasions; but likewise supplying rivers with sufficient to maintaine and make them portable from towne to towne, and for the bettering of lands all the way it runs; with many more advantageous and yet greater effects of profit, admiration, and consequence; so that I deservedly deem this invention to crown my labours, to reward my expences, and make my thoughts acquiesce in way of further inventions." It will be of interest to glance at some of the other inventions recorded by the Marquis of Worcester, for the reason that many of them are curious, and for the further reason that one may see in some of them suggestions which have furnished modern inventors with many of their "original" ideas.

No. 69 describes "A way how a little triangle scrued key, not weighing a shilling, shall be capable and strong enough to bolt and unbolt round about a great chest an hundred bolts through fifty staples, two in each, with a direct contrary motion, and as many more from both sides and ends, and at the self-same time shall fasten it to a place beyond a man's natural strength to take it away; and in one and the same turn both locketh and openeth it." Following this are four other inventions all relating to keys and escutcheons, the latter of which is very curious. When the escutcheon is over the lock,

it has two qualities; the owner though a woman, may with her "delicate hand vary the wayes of coming to open the lock ten millions of times, beyond the knowledge of the smith that made it, or of me who invented it." If a stranger should open it, "it setteth an alarm a-going, which the stranger cannot stop from running out; and besides, though none should be within hearing, yet it catcheth his hand as a trap doth a fox; and though far from maiming him, yet it leaveth such a mark behind it, as will discover him if suspected; the escocheon or lock plainly shewing what monies he hath taken out of the box to a farthing, and how many times opened since the owner hath been in it." Who knows if it be not the case that from these hints some of the ingenious artificers of modern days have borrowed some hints as to locks which are opened by a word; or the time-lock, which only opens at a certain hour and then opens itself, or others of all the marvellous ones which are attached to the doors of the modern safe?

No. 77 is "how to make a man to fly; which I have tried with a little boy of ten years old in a Barn, from one end to the other on a Hay-mow." It is something of a pity that more cannot be learned of this invention; for were it known as to detail, it would save many hard students of this generation the mortification of working to solve a problem, which ever seems on the eve of solution, but which always remains unsolved. No. 78 is a watch to go constantly without winding, except for the first time, and which if consulted daily will keep good time. It is evident that this invention is one in which it is designed to wind the watch by the opening of the case; hence the statement that the oftener it is consulted the better the time that it will keep.

No. 79 is a contrivance for the locking of all the boxes of a cabinet with one key at one time; a method

which is now in use, and which is probably claimed as a modern invention. No. 90 will astonish most people, even in these days when there is no complaint that cheating in gaming has wholly disappeared. It is termed "a most dextrous Dicing Box, with holes transparent, after the usual fashion, with a Device so dextrous, that with a knock of it against the Table the four good Dice are fastened, and it looseneth four false Dice made fit for his purpose." The biographer * of the marquis pronounces his client not guilty of any attempt to provide means for cheating at dice, but thinks that he invented this machine simply for the purpose of warnings to the unwary. As he kept the invention a secret, and would part with only to those who were able to pay for the information, it would hardly seem as if he had invented this machine as a moral example.

No. 92 is the progenitor, or in the line of the descent of the modern dredging machine. It is a "scrue made like a Water-scrue, but the bottom made of Iron-plate Spade-wise, which at the side of a Boat emptieth the mud of a Pond, or raiseth Gravel. No. 93 is an engine by which one man can draw a ship out of the water so that it may be repaired, and let back again without the use of stocks. The next one is a "little Engine, portable in one's pocket, which may be placed to any door, without any noise, but one crack, openeth any door or gate."

Such are some of the more salient of the "Century" inventions of the Marquis of Worcester. The total is a most creditable one, in view of the fact that he was a nobleman by birth, and a politician in practice. He underwent a good many reverses, being at one time wealthy and a court favorite, at another time a prisoner in the

* Henry Dircks.

Tower, and for a considerable portion of his life reduced to the greatest poverty. He has not received the credit he should have from posterity. There are any number of people who have never even heard that there was such a man; and thousands of others who have only heard of him in connection with the ridiculous pot-lid story; in which his attention was called to the existence of steam as a power by seeing the rise and fall of the lid of the pot in which he was boiling his dinner. This is pronounced by his biographer to be false. However, the story does not have to go begging for a companion, this pot-lid, or this tea-kettle; sometimes it is applied to one man and sometimes to another. It is of the greatest value in the instruction of the young. They can remember that steam as a motor was discovered by a young man who was watching a tea-kettle; but they would not be likely to remember it all if they were taught the facts, to-wit: that nobody in particular ever discovered this quality of water; that it has been known and utilized as such from the very earliest period concerning which there are any records.

Dircks, his biographer, speaks of him as having been a learned, thoughtful, studious and good man; a Romanist, without prejudice or bigotry; a loyal subject, free from partisan intolerance; as a public man, upright, honorable, and humane; as a scholar, learned without being pedantic; as a mechanic, patient, skillful, persevering, and of wonderful ingenuity, and of clear, almost intuitive, apprehension.

Before going on with the inventors who succeeded Worcester, it may be worth while to reproduce a document in regard to the claim of Blasco de Garay, the Spanish sea captain, whose claim to have discovered steam as a motor, and the steam-boat, has before been alluded to. In 1825, there was discovered in the national

archives, at Simancas, Spain, a document, of which a translation has been furnished by Hon. George Marsh. It reads as follows:

"Blasco de Garay, a sea-captain, proposed to the emperor and king, Charles V., in the year 1543, an engine to move vessels and large ships, even in a calm, without oars or sails. In spite of the obstacles and opposition which the project met, the emperor ordered trial to be made, and this in fact took place in the port of Barcelona, on the 17th of June, in the year 1543.

"Garay never publicly exhibited his machinery, but at the time of trial it was observed that it consisted of a large caldron of boiling water, and wheels of propulsion attached to the two sides of the ship. The experiment was tried with a vessel of two hundred tons—which had lately arrived from Colibre with a cargo of wheat—called the Trinity, and commanded by Captain Pedro de Scarza.

"As commissioners on the part of Charles V. and the Prince Philip, his son, there were present on this occasion, Don Henry, of Toledo, the governor, Don Pedro Cardona, the treasurer Ranago, the vice-chancellor, the master-accountant of Catalonia, D. Francisco Gralla, and several other persons of condition, both Castilians and Catalans, and among them several sea-captains, who were present at the experiment, some on board, and others on the beach.

"In the report made to the emperor and the prince, they all agreed in praising the machinery, and particularly the facility of the steerage of the ship. The treasurer, Ranago, who was unfriendly to the project, states that the vessel would make but two leagues in three hours; that the machinery was complicated and expensive, and that there was much danger of the frequent bursting of the caldron. The other commissioners

declared, that the vessel would put about twice as quick as a galley by ordinary navigation, and that she made at least a league an hour." *

An expedition taken soon after prevented the following up of the invention, and it was no more heard from. Mr. Marsh endorses the responsibility of the authority of the one from whom he obtained the document.

The facts thus far cited will show that nobody is entitled to claim the merit of being the original discoverer of steam, or the steam-engine.

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* *Nathan Read and the Steam-engine.*

CHAPTER XXIII.

STEAM AND ITS APPLICATIONS.—CONTINUED.

SOME authors reckon the Marquis of Worcester as about the last of the inventors who dealt with steam in what they term the period of speculation, and that the period which followed him was that of application. This is not just to the author of a "Century" of inventions. His application of steam was directly in the direction of the useful. He erected a machine for the raising of water, he enumerated among its advantages the raising of water from mines, then the great desideratum of the mine owners in England. He certainly is entitled, as much as any who followed him, to be classed among those who used steam for practical purposes.

Soon after the death of Worcester, much study was given to steam by men all over Europe, but especially among the English. In 1682, Sir Samuel Morland, an Englishman, furnished some statistics in regard to steam which have not yet had to undergo much alteration. He announced that when water is evaporated by fire, it requires, as a vapor, a space about two thousand times greater than before; and "rather than submit to imprisonment, it will burst a piece of ordinance." Morland is supposed to have constructed some engines worked by steam; and that Savery, in his inventions, was indebted to Morland as well as to the Marquis of Worcester.

In 1698, the famous Savery came to the front as an

inventor, and has occupied a distinguished position as such to the present time. He is often said to be the inventor of the steam-engine; in reality, he was nothing of the kind. That he greatly aided in the utilizing of the new motor will not be denied; he took what others had invented and improved it; and in this direction he is entitled to the most distinguished consideration. His improvements on the engines of the Marquis of Worcester, aided by the suggestions of Sir Samuel Morland, enabled him to claim the proud place of being the first to make steam of wide utility. Daguerre invented the daguerreotype; the man who later so cheapened his processes that every person was able to afford the expense of a picture was not the inventor of the daguerreotype; he occupies the same relation towards the original inventor that Savery does toward the Marquis of Worcester.

Ten years before Savery had produced his engine, Denys Papin had discovered, or invented the safety-valve, having discovered in the course of some of his experiments with steam that it was dangerously explosive. He also produced a species of steam-engine, in which there was a cylinder and a piston. He placed a small quantity of water in the cylinder, and then built a fire under it; as the steam expanded, it raised the piston to the top of the cylinder; and, then, to get the piston down again, he raked the fire from under the cylinder. As it cooled, the steam would condense, and the piston would descend. There have been some improvements since in the processes of getting a piston from one end to the other of a cylinder! Papin was somewhat of a character. He was born in Blois, France, in 1647, and died in Germany, in 1712. He was the inventor of what is known, and still in use, as "Papin's Digester." Being a Protestant, he removed to Germany to escape persecution

and was appointed to a professorship at Marburg, where he devoted such leisure as he had from his mathematical teachings to investigations of steam. His *Acta Eruditorum*, published in 1690, announced that steam will become the universal motive power; it describes a steam-engine, and a steamer to be moved by paddles. In 1707, he published an essay upon raising water by the action of fire; and had a steam-boat built with which to try his system. As there is no record that he succeeded in his experiment, it is probable that it was a failure.

Thomas Savery was born three years later than Papin, in Devonshire, England. He was a military engineer by profession, and possessed of a tendency toward invention. Among his earlier products was a clock, yet in existence, and a set of paddle-wheels to be worked by a capstan, and intended for the propelling of vessels in calm weather. He spent some time in attempting to get it adopted by the naval authorities, without success. "The principal objector was the surveyor of the navy, who dismissed Savery, with a remark which illustrates a spirit which, although not yet extinct, is less frequently met with in public service now than then: 'What have interloping people, that have no concern with us, to do to pretend, to contrive or invent things for us?'"* He failed to get it adopted by the government, although he went to the expense of equipping a vessel with his apparatus, and exhibiting it on the Thames.

His first engine, patented in 1698, was precisely the same as that of Worcester. Steam was admitted from a boiler into a receiver, which, when filled, was disconnected with the steam-pipe from the boiler. Then the steam in the receiver was condensed, creating a vacuum,

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* *Growth of the Steam-Engine.* Thurston.

when, to fill the vacuum, water was forced by the atmosphere into the receiver through a pipe that led to the water below. When the receiver was filled with water, a cock was turned that opened into a pipe that led upwards, and then the pressure of the steam on the water forced it out through this pipe to some point above. All this is very simple. There were two of these receivers, and while one of them was being emptied, the other was being filled. The steam in the receivers was condensed by pouring cold water over the surface of the cylinder. The only point in which he exhibited any difference from the water-raising engine of Worcester was, that he added a second boiler with which to keep the main boiler supplied with water. He would fill this secondary boiler from any convenient source, and then put under it a fire. It had a pipe which ran from its bottom to that of the main boiler; when the steam in the second boiler became more powerful than that in the other, the water from it was driven into the other, and in this way a supply was kept up.

It may readily be imagined that as the action of the receivers was dependent on the condensing of the steam in them by surface-cooling, the action must have been very slow. Accident later improved this defect by revealing a more rapid process of condensation.

Savery's engine was a very fair success considering its defects. He did not use the safety-valve, and in consequence, it did not obtain a foothold in the mines. The height to which the water had to be raised was very great, requiring an immense pressure of steam, which was fatal to the boiler. As the water was taken into the receivers by the force of the atmosphere, the engine had to stand within not less than thirty feet of the water to be raised, and this increased the height to which it was to be forced. In fine, he met with no

success in getting his engines into use in draining mines, although he advertised most extensively, and labored assiduously to secure this class of patronage.

So far as Savery's engine is concerned, it is difficult to see what there is in it which entitles him to the credit which he has enjoyed among posterity. It would seem to be founded largely on the claim that he invented his engine; the facts are as set forth in this work, and go to prove that if he did invent it, he did so under circumstances which would invalidate the claim if submitted to a court of law and a jury. Suppose that, at this stage of the advance of telegraphy, some person who lives within a few miles of Edison, should suddenly come before the public, producing a télephone substantially like that in use, and assert that he had just invented it; that he had never heard of a telephone by Edison, or any other man—what would be the reception which would be given such a claim? And yet such a preposterous assertion would be no more improbable than that which is made in the interests of Savery. He improved somewhat the construction of the engine of Worcester, nothing more.

The first substantial advance made in the use of the steam-engine, after Worcester, was the work of Newcomen, assisted by John Cawley. It is somewhat singular, and much to be regretted, that so little is known of Thomas Newcomen, the man who gave to the world the first engine of real practical value. About all that is known of him is that he was a blacksmith, and that he lived in Dartmouth, England. He does not seem to have had any standing; not being a gentleman by birth, or a graduate of one of the universities, or one able to read the Greek and Roman writers in the original; nobody apparently thought him worthy of any attention. "His position in life was humble, and the

inventor was not then looked on as even an individual of possible importance in the community. He was considered as one of an eccentric class of schemers, and of an order which, concerning itself with mechanical matters, held the lowest position in the class."* And yet Thomas Newcomen is remembered to-day when every one of the tens of thousands who despised him, or men of his class, are as forgotten as if they had never lived.

It is not generally claimed that he invented the steam-engine with which his name is associated, or that he was absolutely in ignorance of what had been done by Savery, then his immediate predecessor. It is even thought by some that he may have been employed by Savery, in his capacity of an iron-worker, to assist in the construction of some of the parts of his engines. Be this as it may, the fact is known that, assisted by John Calley, in 1705, in connection with Savery—for the latter's patent covered surface condensation—took out a patent for what is now known as the Newcomen engine. His new machine had the piston which had been invented and used by Papin in his machine in which gunpowder was the expansive force. He used the vacuum in the cylinder which contained the piston as a means of working a pump, and not as was done by his predecessors, as a vacuum in which the water was driven by atmospheric pressure. He used the walking-beam, in a rude sort of a way, one end carrying the rod of the piston, and the other the pump-rod. In fact, the engine was very simple. The weight of the pump-rod was sufficient to secure the lowering of that end of the walking-beam, and, at the same time, to draw the piston to the top of the cylinder; then steam was admitted below the piston and condensed by the application of

* Thurston.

surface water to the cylinder; this created a condition approaching a vacuum, whereupon, the atmosphere forced the piston to the bottom of the cylinder, raising the pump-rod, and then by its own weight, the pump-rod descended and drew the piston to the top of the

NEWCOMEN'S ENGINE. (A. D. 1705.)

cylinder. Newcomen also used the safety-valve. It will be seen that the engine was an admirable pump with a single defect; that is the loss of time experienced in condensing the steam in the cylinder so as to

permit the ascent of the pump-rod. The method of condensation was that of all who had preceded him, that of cooling by a flow of water over the cylinder. It would naturally take some time for the cylinder to cool sufficiently to condense the steam, and then, when thus cooled, the fresh steam introduced had to warm the cylinder up to a certain degree before it would retain the steam without condensing it. Thus, there was a loss of time in cooling the cylinder to the condensing point, and another loss of time in heating it up to the point where it would retain the steam.

At this point comes in one of those pretty legends which crop out so plentifully in connection with new inventions. It is said that, by accident, a leak was made in the cylinder through which a jet of water passed; and which to the great surprise of the inventors produced the condensation almost instantaneously; the hint was taken, a pipe was arranged so as to throw a jet or spray of cold water into the cylinder when filled with steam; and a great advance was made. The discovery was of very high value; it economized time; it saved the steam which was lost at the moment when it entered the cylinder cooled by the surface process of condensation.

That Newcomen's engine was appreciated is shown by the fact that it became at once in great demand for the drainage of mines.

Newcomen had another happy accident in connection with his engine, and which became the parent of a posterity which is yet in the height of prosperity. It was the suggestion of automatic valve-motion. In his engine, as at first constructed, the valves which admitted the steam above the piston, and the jet of water into the cylinder for the purposes of condensation, had to be worked by hand. Thus, one valve was opened to admit

the steam, and the other was kept closed; when the cylinder was filled with steam, the steam-valve was shut, and the one which admitted the condensing jet was opened. This work of handling the valves was being done by a boy named Humphrey Potter, who, becoming tired of the monotony of alternately pulling these valves open and shut, tied some strings to the ends of the levers, and the other ends to the walking-beam, so that the valves were opened and closed by the motion of the beam. This gave him some time to amuse himself; he was "caught at it;" the value of his process was naturally seen at a glance; the action of the valves was made automatic, and the boy was probably rewarded for his unintentional invention by being discharged, as he had rendered his assistance unnecessary.

Some improvements in construction were made by Smeaton, on the Newcomen engine, in 1769; with this exception, his engine remained as he invented it till the appearance of Watts, in 1764. Thus, the Newcomen engine, with Smeaton's improvements in detail, was in use for something more than half a century.

What it accomplished in that time is worthy of some note.

Very soon after the engine had been introduced to the public, it was employed in all the mines of Great Britain; that is, all of them that required drainage. The advantages to the mine owners was an incalculable one. Many of the mines had been abandoned owing to the impossibility of removing the water; these were drained, and in many other instances, mines were carried far down below the usual level, which otherwise would have remained as they were. Not only were engines thus valuable to the mine owners, but they found employment in other directions. They were used for the supplying of water to large houses, and for water-works. They were

extensively applied to the drainage of marshes in England and in places on the continent.

One of the largest of the Newcomen engines was one built to drain the dry-dock at Cronstadt, Russia. Its cylinder was five and one-half feet in diameter, its stroke of piston eight and one-half feet. There were three boilers, each ten feet in diameter, and over sixteen feet high. There was another built to drain a lake near Rotterdam, whose cylinder was fifty-two inches in diameter, stroke of piston nine feet, a boiler eighteen feet in diameter, with six pumps, and the main beam twenty-seven feet in length.

One of the drawbacks of the Newcomen engine was its use of fuel, it being estimated that the cost of one of them per annum for fuel was not less than fifteen thousand dollars, constituting a tax, which, as was said by one of the mine owners, "amounts almost to a prohibition."

In a certain sense, the engine of Newcomen was not a steam, but an atmospheric engine. The reader will remember that in the description given of its working, it is shown that the pump-rod, in its descent, was weighted so as to draw up the other end of the working-beam, and in this way the piston was drawn to the top of the cylinder. The steam was admitted into the space below the piston, and when filled, it was condensed by the use of water. This left a vacuum under the piston, whereupon the piston was forced down by atmospheric pressure. Steam was only used to create a vacuum; the work was done by the pressure of the atmosphere. The steam-engine was yet to be invented; all that had yet been done was to create an atmospheric engine, in which steam was merely used to enable the atmosphere to accomplish the required work. But Newcomen had made immense progress; he had utilized steam. Nevertheless, he was but a forerunner of a greater who was to follow.

James Watt was born in Greenock, Scotland, January 19, 1736. He came of a good family, his father being a man of fair education, although a carpenter, and who held places of trust in the town in which he resided. The son was very delicate in health, so much so that he was unable to attend school with regularity. Meanwhile, he developed a tendency toward mechanical pursuits, and was placed in a position by the use of tools to acquire dexterity in a practical direction. He gave a good deal of attention to mathematics, and is said to have been phenomenally bright in some branches of mathematics at a very tender age. Of him, there is also related the incident of the boiling kettle, the same which is related of Worcester and Savery; and how the motion suggested to him that steam had a force which might be utilized, and from which grew the steam-engine.

When fourteen years of age, he began to develop some ability as a scholar; at eighteen he was sent to Glasgow to learn the trade of a mathematical instrument-maker. For some reason, he did not remain long; he left Glasgow and went to London. He there worked for a year at the trade he had commenced to learn in Glasgow, when, on account of his health, he was obliged to return home. In 1761, he was installed in Glasgow, where he devoted himself mainly to mechanical pursuits. In 1763, a model of the Newcomen engine was brought to him for repairs, which led him to take up the subject of steam, and steam machinery. At this time, he had educated himself to a fair degree. He had learned to sketch; was a superior model-maker; had mastered some of the sciences, and had studied German and Italian. If his profession had been defined at the time he began to turn his attention to steam, he would have been spoken of as a musical instrument-maker. It was to this class of effort that he principally directed his

labors and studies up to the time that he became interested in steam.

It is related that some four years before this he had given some attention to steam, but gave it up after some brief efforts. Leaving for the moment his connection with steam, the remainder of his biography may be given in a few words. He devoted considerable time to land surveying, and to engineering works of a public character; he invented a micrometer, and was extensively engaged in the manufacture of steam-engines in London. He was the first to apply steam for the warming of houses, and invented the letter-copying press. In 1809, he invented a flexible iron pipe with ball-and-socket joints for the purpose of carrying water across the Clyde, the flexibility being designed to permit the pipe to adapt itself to the inequalities of the bed of the river. At the time of his death, he was a member of many distinguished societies, both British and foreign. He died August 25, 1819; and was buried in Handsworth Church. Those who have visited Westminster Abbey will recollect his statue, a colossal sitting figure, in the chapel of St. Paul—a most imposing work, executed by Chantrey.

On the pedestal is the following:

"Not to perpetuate a name, which must endure while the peaceful arts flourish, but to show that mankind have learned to honor those who best deserve their gratitude, the King, his Ministers and many of his nobles and commoners of the realm, raised this monument up to James Watt, who, directing the force of an original genius, early exercised in philosophical research, to the improvement of the steam-engine, enlarged the resources of his country, increased the power of man, and rose to an eminent place among the most illustrious followers of science and the real benefactors of the world. Born

JAMES WATT. (425)

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at Greenock, MDCCXXXVI. Died at Heathfield, in Staffordshire, MDCCCXIX."

The improvements which Watt made in the construction of the steam-engine were so radical and numerous that they almost amount to its invention. In truth he did construct the steam-engine, for, as said, the Newcomen was an atmospheric engine in which steam was only used to the end that the forces of the atmosphere might be brought into play.

When he had made himself familiar with the workings of the Newcomen engine, he discovered that there was an immense waste of heat; and the first thing he did to check this was to cover the boiler and the conducting pipes with substances that were poor conductors of heat. His final conclusion was that three-fourths of the heat of the Newcomen was wasted, the largest loss being in the method of condensing the steam. As any one can see, the necessity in the Newcomen engine of cooling the cylinder at every down stroke of the piston was a total loss of the heat employed; Watt met this by adding another vessel into which the steam from the cylinder rushed, and was condensed in the added receptacle. This left the cylinder and all its connections always hot, so that fuel was not required to heat them up again to the point at which steam could be admitted without being condensed.

In the Newcomen, the cylinder had but one head, there being nothing above the piston; when the piston descended, the air followed it down into the cylinder, and cooled its surface; Watt added a head to the cylinder, as is now the custom, and had the rod of the piston work through a stuffing-box, which kept out the air, and thus kept the inside of the piston from being cooled at each descent of the piston. It may be worth mention that at this stage of his career, in about 1758, Watt's

partner, Matthew Boulton and Dr. Benjamin Franklin, were in correspondence concerning the construction of a steam-engine, and that a model was constructed which Franklin exhibited in London, but which seems to have attracted no especial notice. In the applications for the patents of his improved "fire-engine" as he terms it, in 1769, he mentions among other things that he "intends in many cases to employ the expansive force of steam to press on the pistons, or whatever may be used instead of them in the same manner as the pressure of the atmosphere is now employed in common fire-engines."

In what he nad thus far done, and which has just been specified, Watt gave to the world the modern steam-engine of the condensing pattern, and which was the same in principle as the condensing engines now in use. He also secured rotary motion, at first, by the peculiar gearing known as the "sun-and-planet" system; a little later and he adopted the crank. It is claimed that he was the inventor of the crank, but that through one of his working-men, a man named Matthew Washborough, obtained a knowledge of the device, and patented it. It was only at the expiration of the patent held by Washborough that Watt was enabled to use his own invention. In 1782, he secured another patent for additional improvements, all of which were important. The claim included (1) the expansion of steam, and six methods of applying the principle and equalizing the expansive power; (2) the double-acting steam-engine, in which the steam acts on each side the piston alternately, the opposite side being in communication with the condenser; (3) the double, or coupled steam-engine—two engines capable of working together or independently, as may be desired; (4) the use of a rack on the piston-rod working into a sector on the end of the beam,

thus securing a perfect rectilinear motion of the rod; (5) a rotary engine or steam-wheel.

The invention of a ratchet on the piston rod to work into a sector on the working-beam was a very ingenious method for securing an unvarying line of motion in the piston, but was soon superseded by Watt's invention of what was called the parallel bars. This was a vast improvement over the other; it has been superseded by the guides and cross-head, which can be seen on any stationary engine in the shape of the contrivances which keep the rod of the piston running always in a straight line. This is also substantially the invention of Watt, as well as are the throttle-valve, the "fly-ball governor," the mercury gauge, an improved valve-gear, and still others that need not be mentioned. It is asserted that so far as the invention of the governor is concerned, he did not invent it, but adapted it from a device that was in use on wind-mills. As is generally known, it is one of the valuable attachments connected with the improvements of the steam-engine; it being so constructed that as the speed of the engine slackens it opens the throttle-valve and admits more steam, and as the engine increases its speed beyond a desirable point, it operates so as to decrease the quantity of steam which is admitted into the cylinder.

Among other machines which Watt constructed was a steam-hammer; one whose hammer weighed over seven tons, which had a drop of two feet, and which would strike three hundred blows a minute. At his death he left unfinished an attempted invention for the copying of statuary by the use of machinery.

The value of Watt's services to the world cannot be over-estimated. In a certain sense, he found it a swamp, and left it dry land. It is not possible to express in dollars the value which came from his drainage of

inundated mines, of swamps, and the saving which he effected in the cost of such labors. He also gave the crank, and the balance-wheel, and thereupon steam became available for the turning of mills, for forging with the trip-hammer, for driving the shuttle, for whirling the spindle, and, in fine, for doing all that which had hitherto been done by water-power, or by machinery driven by hand.

The increase in the power of production demanded a commensurate increase in the supply of raw material, and in the capabilities of transporting the manufactured product to the home of the consumer. There could be but little use in doubling the capacity of the factories and the work-shops, unless there should be a proportionate advance in the means of transportation. The inventions and improvements of Watt made imperative the demand for increased facilities of intercommunication between the producer, the manufacturer, and the consumer. The response to the demand came in due season, in the shape of granting all that was asked. It may, then, be credited to Watt that he not only improved beyond proper characterization the productive facilities of his own period and that of the future, but he created a demand for another vast department of industry, which speedily came in existence. His work was as beneficent to the future as it was to the present; and in this direction it is rare to find a life which has been so far-reaching and comprehensive in its results.

He took the work which had been roughly laid out by the Marquis of Worcester, and improved by Savery, and others, and brought it to completion. He did more than this; he not only completed all that they had designed, but he made infinitely more out of the block to which they had given no more than the faintest of outlines. In fact, he went so far beyond them that he

seems to have scarcely been engaged in the same line except to the extent that he experimented with the same vapor. He produced a steam-engine, they gave the world only an atmospheric engine. It is to the credit of the others, however, that they furnished the suggestion for the perfect machine which he constructed; they supplied some of the foundations on which he built; had they not gone as far as they did, Watt would have had nothing to engage his attention, no errors to invoke his exact scrutiny, nothing on which to found an advance. One of the very things which first provoked his notice was the crudities of their efforts; had he not seen at a glance the wastefulness of the Newcomen engine, he might never have given it an examination.

Before commencing on the era of transportation which succeeded the inventions and improvement of Watt, it may be of some convenience to give in their chronological order the date of the inventions connected with steam, and the name of the inventor. It is to be understood that some of the earlier dates are not always positive.

NAME.	INVENTOR.	DATE.
Æolipile	Hero, (described by)	200 B. C.
Opening Temple Doors	" "	200 "
Description Generation Steam	Besson	1569 A. D.
Steam-boat	De Garay	1543 "
Production Vacuum by Steam	Porta	1601 "
Power Confined Steam	Rivault	1605 "
Raising Water by Steam	De Caus	1615 "
Steam as a Motor	Branca	1629 "
Improvements Use of Steam	Ramsaye	1630 "
Raising Water by Steam	Worcester	1663 "
Gunpowder Engine	Hautefeuille	1678 "
" "	Huyghens	1680 "
Paddle-wheels	Savery	1685 "
Improvements Worcester Engine	"	1698 "
Safety-valve	Papin	1680 "
Engine and Water-wheel	"	1707 "

NAME.	INVENTOR.	DATE.
Engine to Drive Pump	Newcomen	1705 A. D.
Walking-beam, Cylinder, Piston	"	1705 "
Condensing-jet	"	1718 "
Valve-gear, Automatic	Beighton	1718 "
Proper Proportions Engine	Smeaton	1774 "
Steam-engine	Watt	1774 "
Crank and Fly-wheel	"	1771 "
Double-acting Engines	Watt & Boulton	1784 "
Steam-hammer	Watt	1784 "
Steam Governor, Parallel Motion	"	1784 "
Throttle, Puppet-valve, etc.	"	178- "
Oscillating Steam-engine	Murdoch	1784 "
Double-cylinder Engine	Hornblower	1781 "
Rotary Engine	Murdoch	1786 "

CHAPTER XXIV.

STEAM AND THE STEAM-BOAT.

AS was said in the last chapter, the improvements in the use of steam as a motor had vastly increased the productive capacity of the world through the use of machinery; and then there came a necessity for more celerity in transportation in order that the new manufacturing capacity could be supplied and the additional products be carried to the consumer. Very naturally as this necessity forced itself on the attention of the world, the thoughts of those most interested turned themselves to the highways of water. There were the water and the boats; but much of the time, the winds and currents were contrary; ships were detained by the varying tides; they were becalmed by the fitful winds as they died away to nothingness; time was an uncertain element; in fine, the world demanded something more rapid, and less subject to the caprice of winds and tides.

When steam was found to be turning the mills, pumping the mines, draining marshes, and other things, and was showing itself to be obedient to the touch of a child, and yet powerful as a hurricane, men very naturally associated this new power with the slow-going ships. They asked themselves, if this giant can perform all these labors, always tireless, reliable, and willing, why can it not propel these ships? And thereupon began a search for a means of harnessing this new energy to the

vessels that crawled, all too slowly, from shores to shores.

From the time that Watt and his capable assistants brought the engine to the state of excellence which they attained, there were thousands of busy minds engaged in the effort to secure a method of applying steam to the moving of vessels. For a few years before the opening of the present century, there were so many plans suggested to attain this end; there were so many who claimed to have solved the problem, that it is quite bewildering to keep a record of their results, and vastly more so to attempt to reach any conclusion when examining the conflicting claims as to which is entitled to the credit of inventing and constructing the first steam-boat. This country claims this honor; England never suspects that the steam-boat had its origin anywhere save in England, while France is equally certain that the first steam-boat was launched on the Seine. The stately Spaniards look with dignified contempt on all this fierce debate, and point with unswerving finger to Garay, hundreds of years anterior to the dates claimed by the present contest.

There can be no dispute as to priority in the invention of the paddle-wheel, as it was in use among the Romans. The first recorded attempt at steam propulsion of vessels is that which has already been given in detail in another place, that of Garay, in the harbor of Barcelona, in 1543. Worcester, as will be remembered from one of his inventions given in another chapter, speaks of a method of propelling "shipps" without sails, and directly against wind, tide, and current; he undoubtedly referred to the employment of steam. Papin, as already stated, built and ran a model boat, in which a steam-pump was used to raise water to a certain height where it was poured on an overshot-wheel, and this

communicated motion to the paddles. It is impossible to say what the ingenious doctor might have accomplished had the stars been more favorable. He struck a snag and went to the bottom about as soon as his novel craft was launched. The government refused to give him an opportunity for the desired trial; and then a mob of boatmen, who were under the usual impression that the machine was going to take the bread out of their mouths, fell foul of his craft and broke it in pieces. This ended Papin's efforts to establish navigation by steam. In 1736, Jonathan Hull, of England, described a method of propelling a vessel by steam. In his description he placed the wheel at the stern, as he said, for the reason that water-fowl, in propelling themselves, have their paddles behind them. As Watt had not yet invented the crank, he undertook to secure a rotary motion by the use of cords and pulleys, the motive power being an atmospheric engine of the Worcester-Savery-Newcomen kind.

From 1756 to 1760, there were plans for propelling vessels by steam, submitted by Bernouilli, a Frenchman; Genevoise, a Swiss clergyman; and Abbe Gauthier, a citizen of France. In 1760, the epidemic broke out in the United States. According to Thurston, William Henry, a resident of Pennsylvania, and who was born in 1729, in 1760 went to England, where for the first time he saw Watt's invention; when he returned to this country, he constructed an engine and placed it in a boat fitted with paddle-wheels. He tried it on the Conestoga river, near Lancaster, and by accident it was sunk. There is a design in existence of one of his steam-boats. It is related by a German traveler who visited Henry that he showed him a model of his steam-boat, and expressed the strongest faith in the conviction that such a boat would come into use on all the great rivers of the country.

In 1781, the Marquis de Jouffroy, constructed and ran a steam-boat on the Seine. A drawing of the craft shows that the paddle was modeled after the foot of a duck. The boat was one hundred and forty feet long, and fifteen feet beam. In 1783, Jouffroy had finished another boat which he tested at Lyons, and concerning whose success there is not much doubt. However, there was some misunderstanding with the government, the latter declining, for some reason, to guarantee his exclusive use of the invention, whereupon he gave it up, and returned to the army. In 1786, James Rumsey, of Sheppardtown, Virginia, constructed a boat eighty feet long, which he ran at a speed of four miles an hour. He employed steam to work a pump by which water was drawn in at the bow, and expelled at the stern. By many, Rumsey is thought entitled to the credit of the invention of the steam-boat, the State of Kentucky having given his son a gold medal for the sake of the father who had "given the world the benefit of the steam-boat."

In 1785, Dr. Franklin and Oliver Evans suggested a steam-boat to be propelled precisely in the same manner as that constructed by Rumsey. It may be added that this plan has been "invented" several times since, and is now in use in some vessels constructed in Great Britain. In 1786, the well-known John Fitch came before the public. He was totally ignorant, when he commenced his search after a boat to be propelled by steam, that there was such a thing as a steam-engine in existence. He had heard nothing of what had been accomplished by Watt, and, thus, in fact, commenced his investigations, so far as steam was concerned, *de novo*. He and Rumsey conceived the idea of using steam for navigation, at about the same date, and were for a time very fierce rivals. It may be added before temporarily dismissing Rumsey, that he was a man of

much genius, and had he not been struck down by apoplexy, he would have been very apt to have left a different record. His plans—for he had several—for propelling steam-boats were neither all practicable nor original; he failed in one of them, that of using the current of rivers to turn a wheel in the centre of the boat, and this by the aid of a crank, was to secure through setting poles the desired motion. As to the propulsion of water through the stern, this was the plan of Bernouilli, the Frenchman, about 1758. It is shown in the Documentary History of New York that Franklin, after his return from France, had submitted to the Philosophical Society of Philadelphia, in 1785, a plan for a steam-boat substantially like that of Bernouilli, and which was the same as that which was brought before the public by Rumsey.

John Fitch was born in the colony of Connecticut, in January, 1743. The exact locality of the house in which he was born was on the line of Hartford and Windsor; but as the larger portion of the house was in the former, Hartford is usually given as his birth-place. An incident occurred when he was about five years old which he thought presaged his life, and the rewards he was to receive from his countrymen. A younger sister and himself were left alone, when she accidentally set fire to a couple of bundles of flax which were in the room. The boy seized them and dragged them to the fire-place where they could burn out without doing further damage. In the occurrence, he was most severely burned, and the act was that of a hero. The little girl ran out in her fright, and in her confusion, told some of the older children something; they rushed in, and the oldest one proceeded to immediately chastise the scorched young hero in a most severe manner. It was afterwards explained, but he received no apology,

and the event is said to have embittered his whole life.

He was allowed to go to school till he was ten years of age; that is, he was sent to school when there could be found nothing for him to do at home; at ten, he was taken from the school and set at work. He was very bright and ambitious while a boy, but such information as he managed to pick up was gathered from stray books which he could borrow or which he could buy with occasional accumulations of hard-earned pennies. He was apprenticed in time, to a watchmaker, who kept him the most of the time of his apprenticeship at work on a farm which he owned; he married a woman older than himself, and was compelled to leave her; he went to sea for a voyage; and had a desolate, starved life, until a short time before the breaking out of the war with Great Britain, when he managed to accumulate some little money by the manufacture of brass sleeve-buttons, which he hawked about the country. When the war broke out, he was living in Trenton, New Jersey: he enlisted and was made second lieutenant. After the war, he removed to Bucks county, Pennsylvania; and in 1782, he made a journey down the Ohio, and was captured by the Indians. For some time he was with them and was treated with great cruelty, but was finally exchanged at Detroit, and in time reached his home in Pennsylvania. For a couple of years after his return he was engaged in the survey of public lands in Ohio; after this, he was laid up with an attack of rheumatism which produced on him a very curious effect. He was hobbling along from church one day, when somebody driving a powerful horse passed him with great rapidity, which set him to thinking how fine it would be to have some means of getting on without so much pain and difficulty.

He asserts in his papers that he had never heard of a steam-engine, and that he had noticed expansive qualities of steam, and that the suggestion had come to him that it might be used to propel carriages on land. He soon gave up this idea on account of the roughness of the roads, and gave his attention to some form of moving something on the water, which presented no such difficulty as the unmade roads of the country about him. "Although it was not to my credit," wrote Fitch, "I did not know that there was a steam-engine on earth, when I proposed to gain a force by steam." He only learned it when he was given a book, *Martin's Philosophy*, in which there were descriptions of the engines made by Newcomen and Savery.

In 1785 he presented a model of his boat to the American Philosophical Society of Philadelphia. At first he had determined on paddle-wheels, but on reflection he substituted for these an endless chain with floats; this model is still in existence, in the keeping of the society. With the model is an entry of Tuesday, September 27, 1785: "The model, with a drawing and description, of a machine for working a boat against the stream, by means of a steam-engine, was laid before the society by Mr. John Fitch." Another entry of December of the same year: "A copy of the drawing and description of a machine for rowing a boat against the current, which some time ago was laid before the society by Mr. John Fitch, he, this evening presented to them."

There is some very good evidence that Fitch did not obtain his ideas of a steam-boat from Franklin, as has been charged by some, for the reason that Franklin did not advocate the use of paddles, but of the plan first made known by Bernouilli, that of securing motion by driving water out through the stern. In fact, a grandson of Franklin says: "Dr. Franklin, in 1785, planned

a simple method of applying steam to give motion to boats." And then follows a description of the apparatus to be used in forcing the water out at the stern of the boat.*

Fitch had a good deal of trouble as soon as his invention, or rather his claims, had become known. Rumsey had been at work on his plan and produced the machine which was to operate by means of setting poles; there were other claimants in the field; but in July, 1786, Fitch, aided by a mechanic named Voight, succeeded in completing a skiff as a model of his new boat, which was impelled by oars driven by steam. His next difficulty was to raise enough money to construct a large boat; then he met with all sorts of difficulties. He could not raise it by subscription; he appealed to the legislature of Pennsylvania for assistance, and a bill to relieve him was rejected by a small majority. He did, however, succeed in getting a bill through the assembly which gave him the exclusive right to construct, and use on all the navigable water of the state, boats to be impelled by fire or steam. In the same year, his rights were recognized by the states of Delaware and New York. The action of these states had the effect to stimulate the confidence of the public, so that money began to come in, and the building of the boat progressed rapidly.

Fitch and Voight had almost insuperable obstacles to encounter, but they slowly overcame them all, and on the 22nd of August, 1787, the new craft was tried. It went, although it moved but slowly. "The cylinder was only twelve inches in diameter, and the force of the machinery was not sufficient to move the boat at a rate of speed which would render it valuable for use on the Delaware as a packet-boat." As to the success of Fitch up

* *General Advertiser.* Nov., 1791. Benj. Franklin Bache.

to the point mentioned, there can be no doubt; the testimony as to the experiment of the Delaware is abundant and incontrovertible.

While an effort was being made to raise more money in order to enlarge the cylinder, there sprang up a furious controversy between Fitch and Rumsey as to priority in the invention of the steam-boat. The fight was a long and a hotly-contested one, but it is far too long to find any place here. It is probable that the real facts

JOHN FITCH'S STEAM-BOAT. (1788.)

are that Rumsey was the first to think of a boat to move against the current, and that for this purpose he employed the crank and setting-poles, and that he did not contemplate steam as the power, until after the idea had occurred to Fitch and been by him made public. So far as the two men are concerned, it will be about the fair thing to give Rumsey the credit of the first mechanical boat, and Fitch that of the first steam-boat.

The next experiment of Fitch was in July, 1788. The boat had been lightened by being made narrower, a boiler weighing some three tons less than the old one had been placed in it, and the oars were placed at the stern. The boat was loaded with the share-holders, and the banks of the river were lined for nearly twenty miles of the distance traveled. The boat moved along steadily, and was all along received with the greatest possible enthusiasm. It had nearly reached the dock, when the boiler sprang a leak, and the boat came to a sudden stop. However, the trip was a success to the extent of demonstrating that steam could be used as power for the propulsion of a boat. The difficulty was remedied, in a very short time, and the trips were resumed. The average rate of speed attained was four miles an hour; this was not satisfactory to Fitch, and there were some alterations made. In June, 1790, the boat was again tested, and found to be able to make a mile in one-eighth of an hour. From this date the boat ran on the Delaware, carrying passengers and freight. The newspapers of that date are found to contain many advertisements in regard to the hours at which the vessel would leave certain points, and the price of passage from point to point. "Here are no less than twenty-three advertisements, counting all the days of publication, specifying the times at which no less than thirty-one trips would take place, counting each passage from Philadelphia to the place of destination as one. If the steam-boat had done no more than make the passage on the days mentioned, it would have passed over one thousand three hundred and eighty miles. But as the city was small, and the performances of the boat a matter of notoriety, it is quite probable that from June 14th to September 10th, and perhaps for some weeks afterwards, the vessel ran steadily. If we average all the trips at twenty-five miles each, the steam-boat must

have run, before she was laid up, from two thousand to three thousand miles." *

In the New York *Magazine* of 1790, in August, there is an account of the vessel, the statement that she performs admirably, and an expression of the pleasure one experiences in riding on her, as she passes all the other vessels on the river. Rembrandt Peale, in 1848, wrote a letter as to his recollections of this steam-boat, of the number of persons whom he saw on board, and the delight with which he saw it pull out from the dock, and move slowly up the river. Certificates are in existence proving that during this season of the year 1790, Fitch's boat made some wonderful trips; one was when the wind and tide were contrary during a considerable portion of the trip, and yet ninety miles was made in twelve hours, the speed during some portions of the trip reaching as high as from ten to twelve miles an hour, when both wind and tide were favorable.

At this very moment, when the success of Fitch seemed assured, he commenced a rapid decline. The story is too long to tell. His first effort was to get up a company to build a larger boat; this was partly effected, and then through lukewarmness of the men who were to subscribe the money, the scheme fell through. Some of the rights which he had guaranteed him by the states, expired; law-suits were commenced against him by Rumsey; the federal government refused to give him a patent exclusive in its character, but gave to him and Rumsey substantially the same patent, leaving them to fight the matter in court. Fitch became broken down. He went to Kentucky, where he had considerable quantities of land, and undertook to awaken some interest in his schemes for navigating the great rivers with boats

* *Life of John Fitch.* Westcott.

propelled by steam. He failed; grew discouraged, gave everything up; made a bargain with a local landlord to board him and furnish him with a pint of whisky a day during his life, for which he gave him one hundred and fifty acres of land, to which he soon added another one hundred and fifty acres provided the allowance of whisky should be doubled. He died at last by his own hand, from a dose of opium. His death occurred in July, 1798, at Bardstown, Kentucky. He was buried in the public burying-ground, and it was not till 1855 that his grave was discovered. Strange as it may seem, he has as yet no monument commensurate with his achievements. An attempt was made by some Pennsylvanians to have his remains removed to Philadelphia, but some Kentuckians interfered, and promised to give his grave a suitable memorial. The most they ever did in the fulfillment of their promise was to erect a rough stone over his grave without lettering or inscription. The following has been proposed as the inscription on his monument, when a suitable one shall be erected:

His darling wish (he said) was to be buried
On the margin of the Ohio;
Where the song of the boatman might penetrate
The stillness of his resting-place,
And where the sound of the steam-engine
Might send its echoes abroad.
Nihil nihi optatius accidere poterat.

One of his assertions now sounds like a prophecy: "The day will come when some more powerful man will get fame and riches from my invention; but no one will believe that poor John Fitch can do anything worthy of attention." It may serve to illustrate how far advanced navigation was in England to state, that both Fitch and Rumsey visited England for the purpose of urging on the English the advantages to be derived from using steam as a motor for the propelling of vessels. Before his

death, he constructed a toy steam-boat which was propelled by a screw, and of which a model is yet in existence.

In 1785, both Fitch and Rumsey had made claims for a device for the driving of vessels by steam; in 1786–87, Patrick Miller, of England, made an application for a patent for a plan for moving a vessel by steam—at least two years after the same plan as to steam had been patented in this country, or had been brought before at least one philosophical society, and three of the colonial legislatures. In 1788, William Symmington constructed, after a new pattern, an engine with a cylinder only four inches in diameter. The vessel was twenty-seven feet long, seven feet beam, and on a trial made five miles an hour. In 1789, a larger vessel was built for Miller, which, on trial, made seven miles an hour. There was nothing more done in England in the matter of navigation by steam until 1801; in the meanwhile, Miller satisfied with the success he had obtained gave the matter no further attention. In 1789, Oliver Evans, of Philadelphia, built a dredging machine for the board of health of that city. He ran it overland for two miles to the river Schuylkill, then, by means of a paddle-wheel ran up to the Delaware, and thence up to Philadelphia. He also made a contract to construct a steam-boat to run between New Orleans and Natchez; he was well under way with the contract, when the boat was destroyed by a hurricane.

Samuel Morey, of Oxford, New Hampshire, in 1790, constructed a steam-boat with paddle-wheels, which went at the rate of five miles an hour; he constructed a side-wheel boat in 1793; and was in consultation with Fulton, Stevens, Livingston and others; but did not construct anything which survived him. Nathan Read, who will be noticed more at length later, also invented,

or constructed a steam-boat in 1788, but which, except so far as the boiler is concerned, and which is yet in use, did not attain any success. A boat built by Elijah Ormebee, of Rhode Island, in 1792, using an atmospheric engine and a duck's foot-paddle, attained a speed of four miles an hour. *

In 1801, Symmington, who has been before referred to in connection with the construction of an engine for Patrick Miller, constructed a steam-boat for Lord Dundas, and which is famous in the history of steam-boats as the "Charlotte Dundas," and which is claimed by the English to be the first steam-boat built which was a success, and whose use was continuous. It was a paddle-wheel steamer, the wheel being at the stern, and for propelling-machinery had Watt's double-acting steam-engine, connecting rod, and crank, also the invention of Watt. After the completion of the "Charlotte Dundas," she was tried as a tow-boat, and succeeded in hauling two, each of seventy tons, through the Forth and Clyde canal. The vessel appears to have been a complete success; but it was thought that the "wash" would injure the canal, and thereupon she was abandoned. It is stated by Knight that Fulton called on Symmington, and took a trip with him. The "Charlotte Dundas" was the end of efforts at the building of steam-boats in Great Britain; from 1802 to about 1810, there was nothing done in this direction; at that time, Henry Bell constructed the famous passenger boat, the "Comet," and from that period forward, there was no interregnum in navigation by steam in that country.

During this period of inactivity in Great Britain, there was activity in the United States. In 1804, John Stevens, of Hoboken, N. Y., built a steam-boat with a

* Thurston.

screw propeller. It had twin-screws; the boat was sixty-eight feet long with breadth of fourteen feet. The machinery of this vessel is yet in Hoboken, in a state of excellent preservation.

We have the way now clear for the career of Fulton. There is not a steam-boat running anywhere on the water of the earth. Symmington has run the "Charlotte Dundas" into a creek where she is rotting, and from whence she will never emerge. The inventor, himself, a disappointed man, will follow the example of Fitch and die of a broken heart. There is opportunity for some one to come forward, select the merits from all these efforts, reject their defects, and give the world what it so imperatively demands, a steam-boat which will be a commercial and financial success. The man for the opportunity is an American, and his name is Robert Fulton. He is not to be the inventor of the steam-boat; but he is the man who is to gather up all the wasted efforts of the last half hundred years, and crystallize them into success.

Robert Fulton was born, as was Fitch, in Pennsylvania, in the year 1765; like Fitch he was born on a farm, and still again like him he learned a trade. His father was a tailor, who had emigrated from Ireland when young; he married an American woman, and settled on a farm. His father died when he was three years old, and when he became large enough he was sent to the country school, in which, however, he did not learn much, as he was always engaged in contriving or constructing some apparatus. He very early developed ability with the pencil, and in the course of his life achieved some creditable results as an artist.

When about twenty-one years of age, he had succeeded in saving enough money to purchase for his widowed mother a small farm which he gave to her, and

then went abroad to continue his artistic studies under Benjamin West, also a Pennsylvanian, and who then enjoyed a well-deserved celebrity. However, he soon gave up the study of art for that of civil engineer, which was done at the suggestion of the Duke of Bridgewater, with whom he had become acquainted. It was while in England that, according to his biographers, he first became possessed with the idea that steam could be used as a motor for the propulsion of vessels. In September, 1793, he wrote a letter to the Earl of Stanhope, whose nature may be inferred from the reply, and which is as follows: "Sir, I have received yours of the 30th of September, in which you propose to communicate to me the principles of an invention, which you say you have discovered, respecting the moving of ships by steam. I shall be glad to receive the communication which you intend, as I have made the principles of mechanics my particular study." The importance of this letter is in the fact that it gives the date when Fulton had turned his attention to steam, although it was a long time after before he actually gave his attention to devising means to give practical effect to his ideas.

Fulton remained in London till 1797, when he removed to Paris. While a resident of London, he gave his attention to mechanics, and obtained several patents, one of which was for an improved mill for the sawing of marble, another for spinning flax, making ropes, and excavating the channels of canals. During this period, he made the acquaintance of Watt, who had just made his great improvements in the steam-engine, and with which it is certain, Fulton made himself familiar.

While in Paris, he gave a good deal of attention to the construction of a torpedo, and which he tried vainly to sell to the French, and later to the Dutch government. In 1801, he had brought his submarine boat to a

ROBERT FULTON.

state of perfection which has not since been attained, if we may judge of its character from a report made to the French government:

"On the 3d of July, 1801, he embarked with three companions on board his plunging boat in the harbor of Brest, and descended in it to the depth of five, ten, fifteen, and so on to twenty-five feet; but he did not attempt to go lower, because he found that his imperfect machine would not bear the pressure of a greater depth. He remained below the surface one hour. During the time, they were in utter darkness. Afterwards he descended with candles; but finding a great disadvantage from their consumption of vital air, he caused previously to his next experiment, a small window of thick glass to be made near the bow of his boat, and he again descended with her on the 24th of July, 1801. He found that he received from his window, or rather aperture covered with glass, for it was no more than an inch and a half in diameter, sufficient light to enable him to count the minutes on his watch. Having satisfied himself that he could have sufficient light when under water; that he could do without a supply of fresh air for a considerable time; that he could descend to any depth, and rise to the surface with equal facility; his next object was to try her movements, as well on the surface as beneath it. On the 26th of July, he weighed his anchor and hoisted his sails; his boat had one mast, a mainsail, and a jib. There was only a light breeze, and therefore, she did not move on the surface at more than the rate of two miles an hour; but it was found that she would tack and steer, and sail on a wind or before it, as well as any common sailing-boat. He then struck her masts and sails; to do which and to perfectly prepare the boat for plunging, required about two minutes. Having plunged to a certain depth, he placed two men at the

engine, which was intended to give her progressive motion, and one at the helm, while he, with a barometer before him, governed the machine, which kept her balanced between the upper and lower waters. He found that with the exertion of one hand only, he could keep her at any depth he pleased. The propelling engine was then put in motion, and he found that on coming to the surface, he had, in about seven minutes, made a progress of four hundred metres, or five hundred yards. He then again plunged, turned her round while under the water, and returned to near the place he began to move from. He repeated his experiments several days successively, until he became familiar with the operation of the machinery, and the movements of the boat. He found that she was as obedient to her helm under water, as any boat could be on the surface, and that the magnetic needle traversed as well in the one as in the other. On the 7th of August, Mr. Fulton again descended with a store of atmospheric air compressed into a copper globe of a cubic foot capacity, into which two hundred atmospheres were forced. Thus prepared, he descended with three companions to the depth of five feet. At the expiration of an hour and forty minutes, he began to take small supplies of pure air from his reservoir, and did so as he found occasion for four hours and twenty minutes. At the expiration of the time, he came to the surface, without having experienced any inconvenience from having been so long under the water."*

It is very doubtful that in the matter of submarine navigation there has been any improvement on this original construction of Mr. Fulton. He failed to induce the French government to purchase his rights;

* *Biographical Memoir of Robert Fulton.* Prepared by Cadwallader D. Colden, Esq., for the Literary and Philosophical Society of New York.

and then he passed over to England, and undertook to negotiate a sale to the English government; but again met with failure. There has been some criticism of this part of the life of Fulton, that, while England and France were at war, he should pass from the one country to the other endeavoring to make sale of an infernal machine; but this is explained by his friends by the assertion that Fulton's object was peace and not war; that he wished by his machine to make war impossible.

Fulton returned to this country in 1806, and spent some time in trying to induce this government to adopt his torpedo system; but after a time, and after having made some failures, he gave up the torpedo experiments, and gave his attention wholly to efforts to construct a vessel to be moved by steam.

The history of Fulton's connection with the introduction of navigation by steam can be very soon told. As has been shown, his principal occupation during his residence abroad was the construction of the submarine boat and the torpedo, and yet he gave some time to other pursuits. His Stanhope correspondence proves that moving vessels by steam was one of the subjects which engaged his attention. In 1798, the legislature of New York had passed an act in which Chancellor Livingstone was vested with the exclusive right of navigating all boats which might be moved by fire and steam—he having conceived it possible that a new motor might be introduced. This was passed on the condition that he should build such a boat within a year whose progress should be not less than four miles an hour. He made some efforts, but did not meet with the success expected by him. He went to France as the American ambassador, and there formed an alliance with Fulton for the purpose of constructing a boat which should be moved by steam.

Fulton at once gave his attention to the matter. His first essay was the use of endless chains with resisting boards on them as propellors. In 1802, he was at Plombiers, where he constructed models; in 1803, he had constructed another model in which the wheel was introduced; and in the spring of that year, he and Mr. Livingstone had completed an experimental boat, but which was broken by its own weight before there was any opportunity to make any tests. In July, the vessel was repaired, and a test was made on the Seine in the presence of the French officials, and, with the exception that it did not move as fast as was expected, the trial was in every other essential respect satisfactory. Fulton at once ordered from Watt and Bolton machinery which was to be sent to the United States. Mr. Livingstone, also satisfied as to the result of the experiment, wrote over to his friends to have another extension of his exclusive right to employ boats impelled by fire or steam, and this was given by the legislature.

Fulton at once came to America, and commenced building a boat. In the spring of 1807, it was launched from a ship-yard on the East river. It was the "Clermont," the first practical steamboat, and from that day to the present, there has been no cessation in steam-navigation. The first trip of the "Clermont" was made to Albany.

"She had the most terrific appearance, from other vessels which were navigating the river, when she was making her passage. The first steam-boats used dry pine for fuel, which sends forth a column of ignited vapor many feet above the flue, and whenever the fire is stirred, a galaxy of sparks fly off, and in the night have a very beautiful and brilliant appearance. This uncommon light first attracted the attention of the crews of the other vessels. Notwithstanding the wind and tide

FULTON'S FIRST BOAT—THE "CLERMONT."

were adverse to its approach, they saw with astonishment that it was coming rapidly towards them; and when it came so near that the noise of the machinery and paddles was heard, the crews (if what was said at the time in the newspapers be true) in some instances shrunk beneath the decks from the terrific sight, and left the vessels to go ashore, while others prostrated themselves, and besought Providence to protect them from the approach of the horrible monster, which was marching on the tides, and lighting its path by the fires it vomited."*

The "Clermont" was one hundred and thirty-three feet in length; depth seven feet; breadth eighteen feet; burden one hundred and sixty tons; cylinder (one) diameter two feet, stroke four feet; paddle wheels fifteen feet in diameter, two feet dip, and four feet broad; boiler twenty feet long, seven deep, eight in breadth; speed on the first trip five miles an hour. Up to 1812, Fulton had constructed six other steamers, besides one for the western rivers, named the Orleans, and which was launched in 1811, at Pittsburgh. He afterwards built three others for the western rivers, and then gave up the construction of steam-boats, and gave his attention to a submarine battery, for which he obtained a patent in 1813. On the 24th of February, 1815, he died from the effects of a cold caught a short time before, while he had been over to New Jersey as a witness before the legislature to secure a repeal of a law which had forbidden a ferry-boat to ply between New York and New Jersey.

As to the position which Fulton should occupy among those who are entitled to credit for services which they have rendered in securing to the world the

* *Life of Robert Fulton.* 1817. Colden.

FIRST SEA-GOING VESSEL—THE "SAVANNAH."

benefit of navigation by steam, there need be no question. He invented but little; but he was the first to apply principles already established, and give them a practical and lasting effect. He did not invent the steam-boat, but he gave it existence.

The first steam-boat built in Europe which corresponded to the "Clermont" of Fulton, and the "Phœnix" of Stevens, was the "Comet," constructed by Henry Bell, in 1811, several years after river steamers were an accomplished fact in this country. From the time of the building of the "Comet," there was no interregnum in the employment of steam in navigation in Great Britain. Knight quotes from the report of a parliamentary commission which sat in 1817, at which time there were seven steam-boats plying on the Thames, which urges the necessity of steam as a marine, and a river motor, and cites the extensive use of the same in America, "which preceded by some years the establishment of practical steam-vessels carrying passengers in any part of Europe."

In 1818, the Savannah, a steam-vessel purchased in New York, by Mr. Scarborough, a resident of Savannah, Georgia—a vessel of three hundred and fifty tons—steamed from New York to Savannah, being the first vessel to undertake an ocean voyage. She reached Savannah in safety; in May of the same year, she crossed the ocean, reaching Liverpool in twenty-two days. In 1838, two English vessels, the "Sirius" and the "Great Western," crossed from Bristol to New York, in nineteen and eighteen days respectively. The screw for the propulsion of vessels was first brought into notice by John C. Stevens, of Hoboken, New Jersey, the inventor who came so near carrying off the honors from Fulton, as the first to make steam navigation practicable. It was later taken up by the noted Ericsson,

STEAM-SHIP "HAMMONIA."

placed in two vessels which he built for citizens of the United States; and thereafter, to a very large extent, the screw-propeller supplanted the paddle-wheel in ocean-going vessels.

At the present time, the total number of steamers in use in the world, is something over five thousand; this is not inclusive of vessels in use for inland transportation. The total tonnage of these is about three million tons.

CHAPTER XXV.

STEAM AND THE LOCOMOTIVE.

IT has been seen in an examination of the development of the steam-boat, that there is no one person who can be credited with its invention; in the course of the investigation of the growth of the locomotive and the steam-carriage, it will be found that to no one person can be given the entire credit of their invention. Stephenson is usually believed to be the inventor of the locomotive; that is to say, this is the popular conclusion. As a matter of fact, he invented it as little as Fulton invented the steam-boat; he was the one whose locomotive was successful in a test of locomotives. He constructed the best locomotive, not the first one.

It was not till 1602 that the first crude idea of the railway made its appearance in the shape of wooden rails laid down for the wheels of wagons engaged in hauling coal; in 1676, the rails were first laid parallel, and the wheels so constructed that they would not leave the rails. It was not till 1715 that flat plates of iron were nailed to the wooden rails. In 1767, cast-iron rails were introduced, and two years later, flat cast-iron rails with an upright flange came into use. Steel rails of the kind now in use were first made in 1857. It will be seen that the rail was in use long before the locomotive. It may be here mentioned that what is now called the "tram-road" in the old world had its origin in 1791, in the

construction of a railway by Benjamin Outram, in which the upper surface of the rails were convex, and the periphery of the wheels concave. The Outram road has become shortened to tram-road, and is now applied, in England and France, to the street-cars drawn by horses.

The perfection of the steam-engine by Watt led almost irresistibly to the suggestion of its use to supplant horse-power on the tramways. Watt himself suggested that it could be done, but took no steps to carry the idea into effect. Sir Isaac Newton, in 1680, outlined a land-carriage to be driven by steam. It had four wheels, a boiler, from which steam issued through a pipe in the rear, it being intended that the vehicle would move from the reaction of the steam. A man sitting on the front controlled the steam, and steered the carriage. Watt took out patents for engines to run carriages on land, but he never made any use of them. According to Thurston, Dr. Erasmus Darwin urged Boulton, Watt's partner, to construct a steam-carriage, or "fiery chariot," as he termed it.

The first practicable steam-carriage known, is that invented by Nicholas Cugnot, a Frenchman, in 1769, and which is still preserved in the Conservatoire des Arts et Metiers, at Paris. It has a copper boiler, and a pair of single-acting, thirteen-inch cylinders, which communicated power to a single driving-wheel. Thurston, who examined the engine, says of it that it was a very creditable piece of work, and was intended for the transportation of artillery. The connection between the engines and the wheel "was effected by means of pawls, as first proposed by Papin, which could be reversed when it was desired to move the machine backward. . . . This locomotive was found to have been built on a tolerably satisfactory plan; but the boiler was too small, and the steering apparatus was incapable of handling the

carriage with promptness. The death of one of Cugnot's patrons, and the exile of the other, put an end to Cugnot's experiments." *

If there were such a thing as an actual first locomotive, this would be the one, and Cugnot would be entitled to be called its inventor. The fact that his effort did not extend beyond the date of its creation proves that posterity is not indebted to him for the locomotive.

Symmington, whose name has been mentioned in connection with Miller's, and Lord Dundas' steamboats, also in the same year produced a road locomotive. It was a machine that would run over the roads, but nothing came of it. There was another locomotive constructed by Hornblower, in 1769.

In 1784, one of Watt's assistants made a locomotive for use on common roads. This was William Murdoch, of Cornwall. His locomotive was a working model in which the heat for the boiler was supplied by a lamp. It is related that one night he determined to give his model a trial; the heat was applied, the machinery thrown into gear; when the locomotive got away from him, ran out into and along a lane, frightening people with its unexpected and uncanny appearance. Among others who met the smoking, blazing, whizzing object, was the clergyman of the parish, who supposed it was the devil, and set up a vigorous cry for help. That it was a success is shown by the fact that it would move at a rate of speed equal to seven miles an hour. This model is yet believed to be in existence. Why Murdoch did not follow up his model with something larger is not known.

In 1787, Oliver Evans, of Philadelphia, obtained a patent in Maryland for the exclusive right to make steam-carriages for roads and railways. Evans was a

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* *Growth of the Steam-Engine.*

man of considerable note. He was born in Newport, Del., in 1755, and died in New York in 1819. He learned the trade of a wheelwright, and began to devise a land-carriage before he was of age. When but little past his majority, he invented a machine for making card-teeth which had before been done by hand. When he was twenty-four, he was taken in partnership by his brothers, who were millers, and soon after he made some important inventions in mill-machinery, among which were the elevator, descender, conveyor and the like, whose effect was to revolutionize the process of manufacturing flour. Meanwhile he had obtained the right referred to from Maryland in regard to the exclusive use of steam-carriages; but it was not till about 1800 that he found time to give his attention to the construction of this vehicle; but after completing the engine for it, he concluded that it would be of more value to him if applied to the driving of mills. His engine was what is known as high pressure, double-acting; that is, it used steam at a pressure higher than fifty pounds to the inch, and applied it to both sides of the piston. He is claimed to be the inventor of the system of high-pressure, although in England, the credit for this is given to Trevethick. "To Oliver Evans," says Ernst Alban, a well-known German engineer, "was it reserved to show the true value of a long-known principle, and to establish thereon a new and more simple method of applying the power of steam, a method that will remain an eternal memorial to its introducer." He sent his plans to England to secure patents in 1787, and again in 1794–95; and it is probably from this source that Trevethick obtained the hint which enabled him to lay claim to the invention. In 1804, he constructed the steam-dredging machine already alluded to, which he ran on wheels to the river, and then ran to its destination as a steam-boat. It was

named by him, the "Orukter Amphibolos," and was probably the first land carriage ever used in America. He predicted that the time would come, "when people will travel in stages moved by steam-engines from one city to another, almost as fast as birds can fly, fifteen or twenty miles an hour. A carriage will start from Washington in the morning, the passengers will breakfast at Baltimore, dine at Philadelphia, and sup in New York the same day. I have no doubt that my engines will propel boats against the current of the Mississippi, and wagons on turnpike roads with great profit. Engines will drive boats ten to twelve miles an hour, and there will be hundreds of steamers running on the Mississippi river."

It was only the limited means of Evans which prevented his carrying into practice the theories which he entertained in regard to steam as a motor for land carriages and for vessels.

It is stated that, in 1803, a man named Frederick, made a locomotive which was used in connection with a silver mine in Hanover; and that in 1806, a locomotive, driven by hot air, was constructed at Chalons, France, by Niepce.

Trevethick built a high-pressure engine for the propulsion of a road locomotive in 1803. He came in three years behind Evans as the inventor of the high-pressure engine, and some time after Evans' plans and specifications had been on file in London; nevertheless, he is regarded in England as the one to whom is due the credit of the invention. His locomotive was a success; but for some reason, he lost his interest in it, took it apart, and returned to his home with a view of commencing work on a locomotive to be used on a railway.

In 1821, Julius Griffiths, of Middlesex, England, constructed a locomotive for use on a common road. It

was in use for several years. In 1811, an Englishman named Blenkinsop constructed a locomotive for use in the Midland colliery, and which was employed on a tramway. Traction was secured by having spur-wheels which worked into a rack at the side of the track. This is really the first railroad locomotive which is known. It was in use many years, and drew trains of thirty tons in weight at the rate of three and a half miles an hour.

In 1812, it was proved by a series of experiments that the traction could be obtained without any spur or gearing of any kind, which was immediately followed by the patenting of a locomotive with eight wheels, driven by gearing, for the purpose of increasing the adhesion to the rails. In 1813, William Hedley constructed a locomotive which had eight wheels, and which was known as "Puffing Billy." It was used as late as 1862, when it was given a sanctuary in the British Museum. One would be also almost tempted to think that Hedley came as near as any one could of having invented the railway locomotive. In the same year that Hedley invented his locomotive, Brunton invented one in which the driving power was two propellers, jointed so as to imitate the actions of the hind legs of a horse. *

At about 1730, and for some years later, land carriages were very common in England, more especially in London, where they ran with as much regularity as the modern omnibusses. In time all these gave way; at the present time, there are few road locomotives in use in any part of the world.

The modern English world is practically a unit in conceding to George Stephenson the credit of making the locomotive for the railway a practical success; and there is no lack of those who are firmly of the opinion

* Ed.vard H. Knight.

that he is the inventor of the locomotive; that without him, there would have been nothing of the kind, even at the present day. The career of Stephenson is so remarkable that it is worthy of some special attention.

In the mean, little collection of houses known as Wylam, a little west of Newcastle-on-Tyne, George Stephenson was born on June 9, 1781. His father was a very humble workman who filled the position of fireman of the pumping-engine in use at the colliery. At the age of eight years he was made to earn his own bread, and to this end was employed by a woman in the vicinity to herd a few cows of which she was the owner. Of course, it is always the rule to find in the boy some iudications of the man, and in Stephenson's case, history, or legend, furnishes the required material. His favorite amusement while acting as herder was, in company with some other boys, to model engines out of clay. In time he joined his father at the colliery, where he was employed at light work befitting his age. In time he became promoted to fireman, and then engineman, showing an especial fondness for the engine, which he studied till he had thoroughly mastered all its details.

He was a man, getting the pay of a man, and doing the work of a man before he learned to read. After he was eighteen years of age, he began to long for some education, so that he might fit himself for a higher place in his business; and he commenced his studies by taking lessons in reading three nights in a week of a neighboring school-master, at a cost of three pence a week. At nineteen he could read and spell some, and could also write his own name. His next aspiration was for some knowledge of mathematics, and thereupon he began taking lessons in "figuring" at four pence a week. He also gave some attention at odd moments to the mending of shoes, by which he was able to earn a

few extra pence. Among some shoes that were sent him to repair was a pair belonging to a young lady whom he later married, and of whom he probably became enamored on account of something suggestive in the shoe which he had the pleasure of cobbling.

One of the ideas with which he was possessed was that of the discovery of perpetual motion; and it may be added here, lest there be those who may be disposed to disparage him on this account, that many of the brightest geniuses of the middle and later ages have been employed in this pursuit; as was shown in another place. Meanwhile he had been promoted to brakeman, and always gave the closest attention to his duties, and from time to time was able to observe little defects in the workings of the pulleys, or the ropes, and to suggest measures for their remedy. His first opportunity to show his superiority was when an expensive pump had been put up in a colliery, and utterly failed to do the work required of it. Various experts gave it their best efforts, but could make no impression on its obstinate refusal to do what it was expected to do. By accident he was heard to say that he could repair it; and after all others had failed, the overseer, in despair, employed Stephenson to attempt the cure; although he had little if any hope that anything would be accomplished by the raw colliery hand. He took the engine to pieces, and at the end of four days he reported it ready for work. In two days it cleared the pit of water. He received a present of ten pounds for his work, and was promoted to the position of engineer.

In 1813, he had risen to the dignity of being engineer of several collieries; had acquired a fair amount of book knowledge, and by his economical habits had saved a few hundred pounds. At this time, the question of the transportation of the coal from the collieries was attracting

GEORGE STEPHENSON. (409)

a good deal of attention. The Blenkinsop engine had then been constructed, and was at work; Stephenson was among those who saw it, when it was first put on the track, and after watching it for some time, he ventured the remark that he thought he could make a better machine. He found a friend in Lord Ravensworth, who agreeed to advance him the money for his effort. His first engine was very like the Blenkinsop machine, save in a trifling change in the connecting gear, and in the absence of any gearing to prevent the slipping of the wheels on the rail. It had before been proved that a smooth wheel would not slip on a tram-rail; Stephenson thought the same would be the case on an edge-rail; hence he left smooth the periphery of the wheels of his new engine. In 1814, it was placed at work on the Killinworth railway, where, on a gradient of one in four hundred and fifty, it drew eight loaded carriages of thirty tons weight at the rate of four miles an hour.

It was regarded as a success, and was kept at work for some time; but it was found to be inconveniently clumsy and awkward. It was found also that it was not more economical than horses for the work it performed; and had he not been able to increase the value of the fuel burned by the introduction of the steam-blast, his engine would have been thrown aside as not an economical machine. The blast more than doubled the value of the engine.

In 1815, he took out, in company with a Mr. Dodds, a patent for a second engine, whose improvements were the steam-blast, the joint action of the wheels by connecting them with horizontal bars on the outside, and a simplifying of the connection between the cylinder and the wheels.

After the completion of his second engine, he gave

some considerable attention to the construction of a safety-lamp, which he finally perfected under the name of the "Georgy Lamp," and which is still in use in many of the mines, being preferred by some to the safety-lamp of Sir Humphry Davy. The lamp of the latter came out about the same time as that of Stephenson; and there are not lacking those who aver that Stephenson is not entitled to the credit of the invention. It does not follow that because the two lamps were constructed about the same time that one was stolen from the other. However, in the district in which Stephenson lived, he is believed to be the originator of the safety-lamp, while throughout the remainder of the world, the credit, rightly or wrongly, is given to his titled opponent. However, Stephenson lost nothing by it in a pecuniary sense, as his friends, indignant that he should be treated as he was by the partisans of Davy, presented him with a purse of $5,000, and a silver tankard.

After having completed the safety-lamp, he turned his attention to the improvement of railway tracks, and patented an improved rail and chair, whereby the jolting in the track was much lessened. In the same patent, he included some changes in the locomotive; the wheels were to be malleable iron; there was also what may be termed steam-springs for the support of the boiler. There were four cylinders which supported the boiler on the frame of the engine; these opened into the boiler. Within each was a piston, the rod of which rested on the frame of the carriage; within the boiler, the steam pressed on the piston with a force about equal to one-fourth the weight of the engine, and in this way very materially relieved the jar which would otherwise occur. This ingenious process remained in use for some time.

The next matter which engaged his attention was

the construction of a railway for the Hetton colliery, on which his engines were used, five of them being employed on the level parts, while stationary engines were employed for the heavy grades. The road was eight miles in length. In 1825, a railway was opened between Stockton and Darlington, of which he was made engineer; in the meantime, he had opened an establishment for the manufacture of locomotives, in connection with Mr. Pease, in Newcastle-on-Tyne. In 1825, he was employed as engineer of the Liverpool and Manchester Railway; the first railway of any importance in the world. Its completion, and what soon after occurred, gave Stephenson a greater lift into publicity than anything which had ever before occurred in his career. When the road was completed, many of the controlling spirits were of the opinion that the means of transportation should be furnished by stationary engines, as they professed to have no faith whatever in any locomotives which had been created. Stephenson fought this vigorously, and finally succeeded in inducing the directors to offer a prize for the best locomotive for the purpose of the road; they at last consented; and from out this competition grew the world-wide fame which Stephenson has since enjoyed.

The history of this Liverpool and Manchester Railway is a very remarkable one. The two towns were connected by canals, but their business had grown to such dimensions that the necessity of further facilities for transportation became imperative. An attempt had been made to survey the route some three or four years before it was undertaken by Stephenson. All sorts of difficulties were encountered. The residents along the proposed line made every possible resistance. The same was the case when Stephenson went over the ground. He found an army on the watch. His party were ordered off the

farms; they were threatened with legal proceedings as trespassers; they were assaulted, stoned, their instruments smashed; they were followed incessantly by a hooting mob of women and children. All sorts of expedients were resorted to by both parties; work was done early in the morning before the residents were out of bed; some progress was made at meal-times; occasionally some progress was gained at night. Perseverance finally triumphed, and the survey was completed. The estimates were made up, and submitted to the company, who were satisfied, and then the application was made to Parliament for the necessary act to enable the construction of the road.

Here the fight was long and bitter. The canal companies entered the field in opposition, and almost without exception, all the landed interests along the proposed route of the line fought the project from the very outset. The newspapers took sides, but the majority of them opposed it. The people were told by these "organs of public opinion," that the presence of a railway on which there were locomotives, "would prevent cows from grazing and hens from laying. The poisoned air from the locomotives would kill birds as they flew over them, and render the preservation of pheasants and foxes no longer possible. House-holders adjoining the projected line were told that their houses would be burnt up by the fire thrown from the engine-chimneys, while the air around would be polluted by the clouds of smoke. There would no longer be any use for horses; and if the railways extended, the species would become extinguished, and oats and hay unsaleable commodities. Traveling by road would become rendered highly dangerous, and country inns would be ruined. Boilers would burst and blow passengers to atoms. But there was always the consolation to wind up with—that the

weight of the locomotive would completely prevent its moving, and that railways, even if made, could never be worked by steam-power!" *

In 1825, a writer, in referring to the expectations of Stephenson, said: "It is far from my wish to promulgate to the world that the ridiculous expectations, or rather professions, of the enthusiastic speculator will be realized, and that we shall see engines traveling at the rate of twelve, sixteen, eighteen, or twenty miles an hour. Nothing could do more harm toward their general adoption and improvement, than the promulgation of such nonsense." †

The *Quarterly Review* for March, 1825, had an article on the projected railway from Liverpool to Manchester, in which it admits the necessity of the road, but ridicules the idea of traveling more than eight or nine miles an hour; which is something less than the stage coaches, which averaged ten miles an hour. "The gross exaggerations," it says, "of the powers of the locomotive engine, or, to speak in plain English, the steam-carriage, may delude for a time, but must end in the mortification of those concerned. . . What can be more palpably absurd and ridiculous than the prospect held out of locomotives traveling twice as fast as stage-coaches! We should as soon expect the people of Woolwich to suffer themselves to be fired off upon one of Congreve's richochet rockets, as to trust themselves to the mercy of such a machine going at such a rate. We will back old Father Thames against the Woolwich Railway for any sum. We trust that Parliament will, in all the railways it may sanction, limit the speed to eight or nine miles an hour, which we entirely agree with Mr. Sylvester, is

* *George Stephenson.* Smiles.

† *A Practical Treatise on Railroads.* Nicholas Wood.

as great as can be ventured on with safety." This comment was upon a project to build a railway between the metropolis and Woolwich. Dr. Lardner affirmed that carriages could not go at anything like the contemplated speed; if driven to it, the wheels would merely spin on their axles, and the carriage would stand stock still." Evidently the press of that day was as much in the rear of the van of improvement, as in modern days it is in advance of it.

Stephenson was in time brought before the parliamentary committee to whom had been referred the consideration of the application of the grant for the Liverpool and Manchester Railway. The ordeal which he underwent was a long and exhaustive one. The canal companies opposed the grant in the committee, and so did other hostile interests. There was no end to the questions which were propounded to him. He was asked about the effect the increase of speed would have on the security of the track, to which he answered that the greater the momentum the less the weight on the track; as in skating, when a person can cross a weak spot in the ice at a high rate of speed, when the same would give way if crossed at a lower rate. He was asked if the locomotive would not frighten horses; he thought the horses would, in time, become accustomed to it. Would not the wheels slip on the rails; it was impossible that they should so long as the adhesive weight of the wheel on the rail was greater than the weight to be dragged after it. What would become of a locomotive, going at twelve miles an hour, which should come to a curve; it would go round the turn. During the course of the cross-examination before the committee, there occurred an incident which has become famous.

"Suppose, now," asked one of the committee, "that

one of these engines should be going along a railroad at the rate of nine or ten miles an hour, and a cow were to stray on the track; would not that, think you, be a very awkward circumstance!" "Yes," answered the witness, with a twinkle in his eye, "very awkward indeed—for the *coo!*"

The bill was thrown out, but it was again brought up at the next session, and carried. Stephenson was appointed engineer of the construction of the road, and he went at it with his usual vigor. As it approached completion, there was a bitter fight over the power which should be employed in moving the wagons to be used on it. Many were in favor of horses; others were firm in the opinion that stationary engines should draw the trains of wagons from point to point. Apparently nobody but Stephenson was of the belief that the locomotive was of value. Some of the roads which had used the locomotive for the hauling of coal had abandoned it and returned to horses. No engineer of any standing would permit himself to believe that the locomotive was of value, or that it could be made to go as fast as twelve miles an hour without tearing itself and the track to pieces. Two of the most eminent engineers in England, Messrs. Walker and Rastrick, were employed to give a professional opinion on the point, and unanimously decided against the locomotive, recommending that the road be divided into nineteen stations of a mile and a half each, with twenty-one engines fixed at the different points to move the trains.

It was only the pertinacity of Stephenson which saved him from being borne down by this adverse report. Yielding at least to his entreaties, the directors consented to offer a prize of five hundred pounds for the best

* Evidence. p. 207.

locomotive which should be produced by a certain day, under the following conditions:

1. The engine must effectually consume its own smoke.

2. The engine, if of six tons weight, must be able to draw after it, day by day, twenty tons weight (including the tender and water-tank) at ten miles an hour, with a pressure of steam on the boiler not exceeding fifty pounds to the square inch.

3. The boiler must have two safety-valves, neither of which must be fastened down, and one of them be completely out of the control of the engineman.

4. The engine and boiler must be supported on springs, and rest on six wheels, the height of the whole not exceeding fifteen feet to the top of the chimney.

5. The engine with water must not weigh more than six tons; but an engine of less weight would be preferred on its drawing a proportionate load behind it; if of only four and a half tons, then it might be put on only four wheels. The company to be at liberty to test the boiler, etc., by a pressure of one hundred and fifty pounds to the square inch.

6. A mercurial gauge must be affixed to the machine, showing the steam pressure above forty-five pounds to the square inch.

7. The engine must be delivered complete and ready for the trial at the Liverpool end of the railway, no later than the 1st of October, 1829.

8. The price of the engine must not exceed five hundred pounds. *

The same writer says that many persons of influence declared the conditions published by the directors of the railway to be chimerical in the extreme. One

* Smiles.

gentleman of some eminence in Liverpool, Mr. P. Ewart, who afterwards filled the office of government inspector of post-office steam-packets, declared that "only a parcel of charlatans would ever have issued such a set of conditions; that it had been proved to be impossible to make a locomotive engine to go ten miles an hour; but if it ever was done, he would eat a stewed engine wheel for his breakfast."

It was this test which decided the fate of the locomotive, at least for that period. Had the directors yielded to the claims of scientific engineering, to the solemn clamors of the press, to the warnings of the wiseacres of all the professions, to the popular opposition, or even to their own wishes, the locomotive would have put off making its appearance for many years. The conclusion to order a trial, and the results of the test, established the locomotive at once on a footin from which it has never for a moment been displaced.

On the 6th of October, 1829, there were four engines on the ground as competitors for the honors, and the five hundred pounds; they were the "Novelty," the "Sanspareil," the "Rocket," and the "Perseverance." Thousands of spectators were present, among whom were several of the more scientific engineers who had prophecied the failure of the locomotive, and who came probably with the hope of seeing the fulfillment of their vaticinations. One of the three judges was Mr. Rastrick, who had pronounced against the employment of locomotives on the line, preferring twenty-one stationary engines to do the work. The "Novelty" was the first called out; the trial track was two miles in length, level, and well adapted to the purposes of the test. It was an engine which weighed a little over three tons, with a blast furnished by a bellows. It made a few runs back and forth, making in some cases as many as twenty-four

miles an hour. In the final tests, the "Novelty" performed excellent work, but burst a pipe, by which it was forced out of the competition. The "Sanspareil" made an average speed of about fourteen miles an hour, but it burst a water-pipe before the trial was over, and it too lost its place. The "Perseverance" could only make about six miles an hour, and this left the field to Stephenson's engine, the "Rocket." It worked "like a charm." It did all that the competition called for,

THE "ROCKET." (1829.)

and a good deal more. During its test, its average speed was fifteen miles an hour; in a certain part of the trial its average was about twenty-nine miles an hour.

It ought to be mentioned at this point that one of the most material of the elements which led to the success was the superiority of its boiler, which was known as the multitubular, and which was an American invention, having been invented and patented by Nathan Read, in 1791, nearly forty years before the trial in

which the "Rocket" won the prize. Indeed, Smiles, the biographer of Stephenson, does not assert that Stephenson was its inventor; but he is careful to suggest that various Englishmen had used it prior to its use by the "Rocket." He does even go to the length of admitting that there was a still prior claim made by a Mr. Stevens, of New York, who claimed to have used it as early as 1807; and then it is said by Robert Stephenson, the son of the great engineer, "but certain it is that the perfect establishment of the success of the multitubular boiler is more immediately due to the suggestions of Mr. Henry Booth, and to my father's practical knowledge in carrying it out."

Stephenson lived till 1848, and was able to witness a development of the locomotive and the railway which more than answered his most ardent expectations. He was great in his self-culture, great in his ingenuity and perseverance, but the greatest of the things which he accomplished was in his waging a conflict, almost single-handed, with all England for the introduction of the locomotive on the Liverpool and Manchester Railway. His victory, won after gigantic efforts, and against incredible odds, was not merely a personal triumph of the grandest dimensions; it was also a victory of incalculable value to commerce, to labor, and to the world's advancement. It is true that had he not made the fight, it would have been made, and would have been won by some later athlete. The delay might have cost the world ten or even twenty years of its progress; without Stephenson's victory, the world might be to-day where it was ten or twenty years ago. The locomotive is at the head of modern advancement. Without it a steam-marine would be a mere shadow of what it is at the present time.

This century has a vast debt to Stephenson. He was

far in advance of his time; and he drew the world up to the point which he had gained. His moral life is likewise of the greatest value on account of its character; it proves that there is no bar to the progress of the poorest, the most humble. Stephenson could have received a title, and he refused it; he is better remembered as the Great Engineer, than he would have been had he been gazetted a prince. What he accomplished is within the reach of all others who have natural ability, backed by industry and perseverance.

Since the establishment of the thirty miles of the Liverpool and Manchester Railway, fifty-four years ago, there has grown a system in the United Kingdom which includes over eighteen thousand miles of roads, some fourteen thousand locomotives, over four hundred and forty thousand vehicles for the transportation of goods, passengers, etc., and some seven hundred million pounds of capital, yielding a return of over thirty million pounds. Is not this figure of the income from the railways something which reflects infinite credit on the man who procured the substitution of the "Rocket" for stationary engines to be placed one and a half miles apart, with ropes, pulleys and the like for the hauling of the trains?

The first railway was laid in France about 1823, for the purpose of hauling coals, and the horse was the motor at first used; these gave way to engines. Locomotives were not used till near 1840. Belgium and Germany very soon followed the example of Great Britain in the use of locomotives for railways.

The first railway in the United States was one built from Quincy to Milton, Massachusetts, a distance of two miles, in 1826. The first locomotive in this country was constructed by Col. John Stevens, of Hoboken, in 1825, and was shown to be a success by being run on a circular track in front of his residence. The next, so far as

known, was built in 1829, by the late Peter Cooper, and although but an experimental machine, with a three and a half inch cylinder, and rated at one-horse power, it ran on the Baltimore and Ohio Railway at the rate of eighteen miles an hour, drawing a coach containing thirty-six passengers.* The first locomotive in use in this country was on the Delaware and Hudson Canal Company's Railway, and was built by Rastrick, in England. It was found to be unequal to the work required of it, and was followed by the use of American-made locomotives. The first locomotive built in this country for use on an established railway was the "Best Friend," built at the West Point foundry, in 1830, for the Charleston and Hamburg Railway. From this time forward, this country has supplied its own locomotives, and so successful have been some of the types constructed that, in the case at least of the "George Washington," built by the celebrated Norris, several of the same kind were ordered for use on the British railways.

That this country commenced to supply itself with locomotives proves the value of its mechanics. They were not copyists in any sense of the word, none of the machines produced here being in any sense reproductions of the English models. Even at this date, the English and American locomotives are unlike in many respects. They have but little external resemblance; and it is the opinion of experts that the American engine is in all essential respects the equal of the English machine, and in many particulars its superior.

The increase of the miles of railway in this country since the inauguration of this first railway has been commensurate with the growth of the rest of the country. The United States now have about eighty thousand

* Thurston.

miles, or more than all Europe together, or perhaps all the rest of the world. We have about eight times as many miles as France; more than four times as many as Great Britain; eight times as many as Russia; nearly twelve times as many as Prussia; and about twenty times as many as Austria. The amount of capital invested in railways in this country is over four and a half billions of dollars; and the total receipts over six hundred million dollars per annum.

The following will afford a chronological sequence of the various inventions and discoveries in the steam-boat and the steam-carriage. The dates are approximately correct:

THE STEAM-BOAT.

Garay	1543	Fitch	1787–8
Papin	1690	Miller	1787–8
Hulls	1736	Read	1789
Bernouilli	1750	Morey	1790
Gauthier	1750	Ormsbee	1792
Henry	1770	Dundas and Symmington	1802
D'Auxiron	1770	Fulton	1803–7
Jouffroy	1770	Stephens	1805
Rumsey	1786		

STEAM CARRIAGES.

Newton	1680	Blenkinsop	1811
Cughnot	1769	Hedley	1813
Symmington	1769	Brunton	1813
Hornblower	1769	Losh and Stephenson	1815
Murdoch	1784	Griffith	1821
Read	1790	Peter Cooper	1829
Trevithick	1803	West Point foundry ("Best Friend")	1830
Evans	1804		

Of the other applications of steam, nothing will be said in this connection. Nor is it necessary to enlarge on its value in the development of civilization. This is patent to the most superficial thinker. That it has revolutionized travel, transportation, and manufactures; that it has broken down geographical, and almost coëxtensively, political boundaries is recognized by every

one. Much of the old hostility of nations once grew from jealousy of each other; they erected barriers, and fancied that their security depended on their isolation. Now this has all been removed among civilized peoples. Steam has produced a solidarity which could have been produced in no other way. There has grown up an inter-dependence which is potent in restraining hostile feeling, and which forbids wars, except under the most inevitable circumstances. So intimate and valuable have become the commercial relations of the various countries, through the agency of communication by steam, that it is against the public policy to permit their disturbance by war unless there is no other resource. Even as the motor of the iron-clad, it is engaged in a mission of peace; for, the more effective and formidable become the implements and engines of war, the greater is the tendency to peace.

In fine, within the last fifty years there has been a more rapid development of the commerce, wealth, the comfort, the general intelligence of the world, than in any two centuries, apart from this period, which the nations have known. In this development, steam has been the most potent factor.

CHAPTER XXVI.

ELECTRICITY AND ITS APPLIANCES.

THERE is no possible utility in a popular work like the present one to attempt any explanation as to the nature of electricity. One of the essential reasons for not attempting it is that its nature is unknown. Its phenomena may be; but nothing more. Chemistry cannot analyze it; there are no symbols which will explain its composition; we know what it will do; what it is, is a profound secret, and may always remain so. To show how little is known, an extract may be given from the ablest of modern writers on electricity. He says at the outset that it has not yet been positively decided what electricity is, but the most favored idea is contrary to its being material. The best known theories treat it as a substance existing in the form of two fluids or one. In the former, every non-electrified body has an enormous and equal quantity of each of the electric fluids in it, and they are then said to be neutral, fixed, or combined; so great is this quantity, that by no possible electrification can a body be deprived entirely of either kind. These fluids have no mass nor weight, nor any other property of fluids, save that of mobility, and attraction and repulsion. They are not confined to the molecules of the body, and can be separated — one fluid being drawn to one part of the body, and the other to the opposite. They may also pass from one body to another.

The molecules of either fluid repel like molecules, and attract those of the other fluid, with a force varying inversely as the square of the distance between them. The single fluid theory supposes that all bodies are composed of two kinds of material particles—one ordinary matter, and the other electric fluid. The former has all the properties of matter; the latter has only mobility, and attraction, and repulsion. The particles of matter repel other particles of matter, but attract the particles of the fluid with a force varying inversely as the squares of the distance between the particles. The particles of fluid have similar properties; but the attraction between any given quantities of unlike molecules is slightly greater, than the repulsion between the same quantities of like molecules when the other conditions are the same; consequently there is a slight resultant attraction between an amount of matter in combination with an equal amount of fluid, and another similar combination of matter and fluid. When equal quantities of matter and fluid are present in a body, it is non-electrified, and the matter and the fluid are then said to be combined. When more fluid than matter is present, the body is positively electrified; when there is a deficiency of the electric fluid, the electrification is negative." *

This explanation is one of several; and should be considered in connection with the assertion that "it has not been positively decided yet what electricity is." For all popular purposes electricity may be regarded as in the nature of a simple fluid which moves through the spaces of a conducting object at a speed so rapid that practically no time is taken up in the transmission.

It is more than two thousand years ago that it was known that some objects when excited bv friction would

* Ferguson.

attract other objects. The substance known as amber was the most sensitive to this influence; the Greek name of the amber being *elektron*, we get from it electricity. This was electricity as originally known; and for all practical purposes it is the same fluid which to-day goes blazing and roaring through the air when there is a thunder-storm; the same as that which is evolved by chemical decomposition in the various batteries in use; the same as that which is produced by the use of dynamo-electric machines which generate electricity for light, and the energizing of motors; the same as that which dives into the ocean and swims to the further shore, and in a second's time delivers the message which it has been charged to deliver; and the same as that produced by the various friction machines. There are many ways of coaxing this shy but mighty power into an active existence; but however produced, it is substantially the same always, with the same steely flame, the same nimble spark, the same murderous nature when not under control; the same energetic servant and slave when held steadily under command.

This is enough to know in regard to this agent unless one wishes to lose one's self in the mazes of the theoretical and the unknowable.

The most important use to which electricity is put at the present day is that of telegraphing. It is supposed to be an invention of yesterday; in reality, it is more than a century old; that is, the first telegraph which, by the means of electricity, conveyed signals between distant points. There was a telegraph back of this one, but it had its existence only in the dream of an enthusiast; and yet it foreshadowed the modern telegraph with an astonishing accuracy. In 1617, it was suggested by a Roman writer, Famianus Strada, that two friends could hold a conversation, however widely they might be

separated, by the use of a marvelous loadstone, and a steel needle. A dial containing all the letters of the alphabet was arranged upon a plate, and over these the needle was suspended so as to be able to move freely in every direction. Each of the two being provided with a dial-plate and loadstone, was in condition for conversation, although separated from the other by an ocean. Whenever one touched a needle with his loadstone, and held the needle over a certain letter, the needle on the dial of the other moved to the same letter; and in this way communication was carried on.* Given the dial-plates, the loadstones, the steel needles, with the addition of an electric current, and we have all there is of the telegraph of to-day. There were suggestions of an electric telegraph as early as 1750, in which it was proposed to suspend twenty-four insulated wires between distant points, each wire to represent a letter of the alphabet, at the end of each being a bell to be rung by an electric current sent through the wires.†

This is just as much an electric telegraph as any in use at the present day. The first telegraph to use electricity was in 1774, and was the product of Georges Louis Lesage; it had twenty-four wires, each ending in pith-balls, each of which represented a letter. Lesage, in 1782, asserted that he had the method in his brain for the telegraph which he produced, some thirty-five years before he carried it into practice. Arthur Young, an Englishman, who traveled through France in 1787, 1788, and 1789, thus speaks of a very ingenious mechanic, named Lomond: "In electricity, he had made a remarkable discovery. You write two or three words on a piece of paper; he takes it with him into a room, and turns a

* *Prolusiones Academicæ.*

† *Scott's Magazine.* February, 1753.

machine enclosed in a cylindrical case, at the top of which is an electrometer, a small, fine pith-ball; a wire connects with a similar cylinder and electrometer in a distant apartment; and his wife, by observing the corresponding motions of the ball, writes down the words they indicate. From which it appears that he has formed an alphabet of motions. As the length of the wire makes no difference in the effect, a correspondence might be carried on at any distance." *

In 1794, according to *Voight's Magazine*, Reiser, of Geneva, constructed a telegraph in which there were thirty-six wires, which represented the twenty-four letters and the ten numerals. In this there were narrow strips of tin-foil pasted on glass at the receiving station. "The instant the discharge is made through the wire, the spark is seen simultaneously at each of the interruptions or breaks of the tin-foil constituting the letter, and the whole letter is rendered visible at once."

In 1795, Tiberius Cavallo, of England, published a plan of an electric telegraph, in which he suggested that by sending a number of sparks along a wire, a system of communication could be established by the length of time between the sparks, which is about the same thing to the eye that reading from sound is in the case of the Morse system. In 1797, Don Francisco Salva, of Spain, constructed a telegraph line of twenty-six miles in length; the next year, Betancourt, of the same nationality, also erected a telegraph line, both of which proved a success. The means used was the electric current for explosion in the Leyden jar, the difference in the rapidity of the appearance of the sparks indicating the sign intended to be conveyed. The next attempt of importance was that of Francis Ronalds, at Hammersmith,

* *Travels in the Kingdom of France.* Arthur Young.

England, on a line eight miles in length. His telegraph was so very excellent that, many years later, it was substantially reintroduced in the well-known Hughes telegraph, the invention of David E. Hughes, a Kentuckian. The plan of Ronalds included a clock at each end of the wire, both so arranged as to run exactly together, and each having lettered dials. Before each was a screen which permitted one letter only to be seen; when this letter was before the opening, the discharge was sent; "the electrometer at the far end then diverged, and thus informed the receiver of the message which letter was designated by the sender."

The earliest known telegraph in this country was constructed by Harrison Gray Dyar at the race-course on Long Island, in 1827. His plan was to send electrical currents through wires in the usual way, to be received on litmus paper. Each discharge made a red mark; the difference of time between the different discharges was the key of the signs. As in all the other cases which preceded the last-mentioned, the electricity was produced by friction. Of these cases it is said by an expert electrician that they are in no sense as trivial and inefficient as they are so often represented by modern writers. "On the contrary, but for the practical difficulty of perfect and constant insulation, owing to the intense self-repulsion of mechanical electricity, and the reaction and retardation from induction currents in long lines of coated wires, this method would really constitute an economical and satisfactory medium of distant communication." *

In 1800, Allessandro Volta, an Italian, discovered and constructed what is now known as the Voltaic pile, or in other words, a chemical battery by which

* *Henry and the Telegraph.* W. B. Taylor.

electricity could be produced in greater quantities than by the usual frictional methods. He was born at Comò, February 18th, 1745, and died at the same place April 5th, 1827. He was of a noble family, was properly educated, and began at an early period to make a study of electricity. In 1775, he constructed an instrument for the generation of electricity, known as the electrophorus, and in 1782, he made other discoveries in the production of electricity; but his greatest invention was that of the pile. His electrical discoveries up to this point had been of apparatuses for generating electricity by friction; but at this time, in 1800, he discovered a chemical method for producing the same results, only they were very much increased as to value. His discoveries were received with the greatest enthusiasm by the scientific world, and he thereafter was the recipient of the very highest honors.

The voltaic pile consists of a number of circular plates of copper and zinc; each plate being made up of a plate of copper and one of zinc soldered together, and with each pair of compound plates separated by a woolen cloth moistened with a solution of salt, or dilute sulphuric acid.

The first one to avail himself of the new method was Dr. Thomas Sæmmering, of Munich. He constructed an apparatus by means of which he succeeded in sending signals through two miles of wire. His signals were obtained by the decomposition of water in thirty-five test-tubes at the receiving station, the tubes representing the alphabet and the numerals. This was in 1808. The only difficulty with his invention was its lack of simplicity. It required thirty-five wires between the stages, but in other respects, it performed well all that was required of it. In 1810, Dr. John Coxe, of Philadelphia, proposed almost precisely the plan of

Sæmmering, without being aware that it was already in existence; and he added the suggestion that signals might be conveyed by currents which should decompose metallic salts. About the same time, Schweigger proposed a method by which the thirty-five wires of Sæmmering could be cut down to two.

In 1828, a Frenchman proposed a telegraph line from Paris to Brussels, which should consist of a single wire, which should be laid underground for the entire distance. In 1843, Robert Smith, of Blackford, Scotland, constructed a telegraph which had but two wires, and which recorded by means of the decomposition of metallic salts. In 1846, Alexander Bain, of Edinburgh, obtained a patent for a form of telegraph which was essentially in principle like that of Smith three years before. In 1849, the well-known Professor F. B. Morse, of New York, patented a telegraph, in which there was a single circuit as in that of Smith, and in which the recording was done in metallic salts as in the case of those of the Scotchmen, Bain and Smith.

The effort of Prof. Morse was the last of those directed to securing means of communication at a distance by the application of the galvano-chemical processes. It needed something yet more efficient in the shape of electro-magnetism. This came in due season, and since its discovery, the advance in the use of electricity has been as rapid as the use of steam after the improvements and inventions of Watt, or of locomotives after the "Rocket" had won the first prize for George Stephenson.

It would scarcely be the proper thing to do in a popular work to explain the properties of magnetism, and the resultant of its union with electricity. Perhaps all that need be said is, that a soft iron bar, if surrounded by copper wire, and a current of electricity be

passed through the wire, the iron becomes magnetic. Another fact may be stated—and this is almost at the very base of electro-magnetism—that if a current of electricity be passed through a wire, and the wire be held above and parallel to a magnetic needle, the latter will at once turn at right angles to the current, and thus remain so long as the current is continued. This discovery seems a very little one, yet when the fact became known that a current would thus deflect the needle, through a Dane, named Hans Christian Anderson, in 1820, and was given to the world, it created more comment and curiosity than any other single development connected with the advance of electrical science. It gave to the world the galvanometer, an instrument of almost inestimable value in the various operations connected with the uses of the electric current. As soon as this fact became known, the famous Andre Marie Ampére, suggested that it might be made of value as a means of communicating between distant points; but, as in many former cases his system was too cumbrous to be of value. He too, had as many wires as there are letters, and numerals, and as many needles as wires and letters, with a name of a letter to each needle. In working this telegraph, it was only necessary to touch the wire, say of the letter "A," whereupon the needle "A" at the other end of the line would be deflected, and at once the reader would know what letter was intended. The telegraph of Ampére was very much improved by Baron Paul Ludovitsh Schilling, of Cronstadt, Russia, in the year 1823. He reduced the number of needles to five, in his first experiment; and later, on the authority of Dr. Hamel, he succeeded in operating with only one needle. The length of the wire through which he succeeded in conveying the signals is not given; it is indefinitely stated at "considerable;" and in the same

way are we ignorant of the rapidity with which communication could be made, or the signals read. It seems tolerably certain, however, that he did succeed in inventing a system in which a single needle was all that was required, the various letters being represented by a certain number of deflections to the right or left.

In 1825, Sturgeon, of Woolwich, England, substituted soft iron for steel, and this was the first appearance of what is known as the electro-magnet. It consisted of a small bar of soft iron bent into horse-shoe form, wound loosely with a copper wire. In 1828, and in 1829, Prof. Joseph Henry, of Albany, N. Y., introduced a material improvement in the character of the electro-magnet. It is described by Henry as a round piece of iron, about one-quarter of an inch thick, bent in the form of the horse-shoe; and instead of the few feet of wire coiled about it as in the Sturgeon magnet, it was wound closely with thirty-five feet of wire (the wire being wound with silk), making about four hundred turns around the iron, to accomplish which the wire was coiled on itself.

The construction of this form of magnet added enormously to its power. It is stated that, up to this time, the strongest magnet in Europe was that of Sturgeon, which, with one hundred and thirty square inches of surface of zinc in the battery, sustained only nine pounds; while the Henry magnet, with only two and a half square inches of zinc surface in the battery, sustained a weight of fourteen pounds. The value of his improvements is, that currents could be sent through long distances of wires. What he did made the present telegraphic system a possibility. According to the biographer of Prof. Henry, seven years after he had experimentally demonstrated the conditions required for "magnetizing iron at great distances through very long

conducting wires, Prof. Charles Wheatstone, of King's College, London, having found a difficulty in signalling through four miles of wire, was able to work out the problem for his own telegraph, by help derived from Henry's labors. And yet he permitted his colleague, Prof. John F. Daniell, to state: 'Ingenious as Prof. Wheatstone's contrivances are, they would have been of no avail for telegraphic purposes without the investigation, *which he was the first to make*, of the law of electro-magnets, when acted on through great lengths of wire.' And this erroneous declaration was made long after Henry's 'quantity' and 'intensity' magnets had been employed in the experiments of European electricians; and years after Wheatstone had formed the acquaintance of Henry, and, in April, 1837, had learned from his own lips an account of his elaborate investigations and successful results." *

In 1831, Prof. Henry suspended a mile of wire around a room in the Albany Academy, connecting a small Cruickshanks battery, and an intensity magnet. A permanent magnet, in the shape of a small steel rod was suspended near the intensity magnet, so that it could move freely. When a current was sent through the wire, the excitation of the soft iron magnet repelled the permanent magnet which touched it at one of its ends, and then it was drawn to the other limb of the electromagnet. As it passed from one limb to the other, the free end struck a small bell. It is easy to be seen that this telegraph contained all the essential principles of the Morse system of to-day. Originally the Morse system was remarkable in that it recorded the messages which it received; now it is read by the ear; and in this particular, it is precisely what Henry's was in 1831.

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* *Henry and the Telegraph.* Taylor.

There is a small difference in detail between the two systems; in the case of the Morse telegraph, the excitation of the magnet moves a flat bar of metal known as the armature, whose click as it strikes a post near the ends of the magnet, is the signal which conveys the desired meaning; in the other, the magnet gave motion to a suspended steel bar, which gave the signal by striking a bell. Here is to be found all the principles of the successful electro-magnetic telegraph.

In 1833, Gauss and Weber constructed a galvanometer telegraph in Göttingen, for a distance of over a mile and a half. The alphabet was made up, as in later telegraphs of the kind, from right and left deflections of the needle. Three years later, in Munich, Prof. C. A. Steinheil, at the request of Gauss, took up his telegraph for the purpose of improving it. He suspended the wires in the air for a distance of about two miles. He succeeded in making some improvement, but the most valuable of his discoveries was that the earth might be used to complete the "circuit," instead of using an extra wire for the return of the current.

In 1837, Cooke and Wheatstone patented, on June 12, a galvanometer telegraph, which had no essential unlikeness to that first constructed by Baron Schilling. There are not wanting those who assert that Wheatstone owes his success to the improvements in magnets made by Prof. Henry. At the outset, he experienced great difficulty in the feebleness of the currents in attempts to use it for considerable distances; and although Henry's improvement had been before the world several years, and although Henry had visited London and conversed with Wheatstone (the latter only a couple of months before Wheatstone overcame his difficulty), yet Wheatstone claims expressly to have discovered the electro-magnet which enabled him to meet

with success. Either this is a misstatement of the facts, or else Prof. Wheatstone was strangely ignorant of what had occurred in the scientific world.

Three months after the application of a patent for a galvanometer telegraph, Morse filed a caveat for the invention of the electro-magnetic telegraph; the patent was obtained in 1840, and the first practical use of it was May 27, 1844, on a line between Washington and Baltimore.

Whatever may be the facts as to the inventions which preceded his, there is no question of the fact that Morse did more than all others who were in advance of him to bring the telegraph from little more than a toy into the practical thing it is to-day. He is not the inventor of the telegraph, as many suppose, any more than Watt was the inventor of the steam-engine; in fact, he was to the telegraph what Watt was to the steam-engine; he made it what it is. Samuel Finley Breese Morse was born in Charlestown, Massachusetts, April 27, 1791, and died in New York, April 2, 1872. His father was the well-known geographer, and was also a historian, preacher and editor. The son was a graduate of Yale College, after which he went to England, and studied painting under Benjamin West. He gave some attention to sculpture, and received a medal for one of his efforts with the chisel. He gave his attention to his profession till he was thirty-eight years of age, and then again visited Europe in the interests of art, and remained there three years. At the close of his visit, in 1832, he had become very much interested in electrical studies; and it is said that, at that time, became possessed with the idea that he could construct a telegraph to be operated with electricity, and also electro-magnetism. It is asserted that the conception was entirely an original one with him, and such may be the case. It is

SAMUEL F. B. MORSE.

difficult, however, to comprehend, in view of what had been done in both these directions, that he should have known nothing of it, the more so that he was a man of education as well as a man of information; unlike poor Fitch, who conceived the idea that steam might be used as a motor, a century or longer after it had been in practical use. In view of the testimony of the passengers of the ship on which he was coming home from Europe, the year 1832 is fixed by his biographers as the date of the conception of the telegraph by Morse as a wholly original idea. There was one passenger who did not agree with this claim, and who afterwards entered the courts to dispute the claim of Morse to originality in the invention of the telegraph. The name of this witness was Dr. Charles Thomas Jackson, who, later in life, claimed to be the discoverer of anæsthetics, and for which he received one-half of the five thousand francs given by the French Academy of Sciences; the half being given him for its discovery, and the other half to Dr. W. T. G. Morton for his application of etherization to surgical practice.

Dr. Jackson asserts that on the voyage over, in 1832, he had an electro-magnet, two galvanic batteries, and some other philosophical apparatus; that a discussion arose between Prof. Morse, himself and others, in regard to the practicability of correspondence; and that he pointed out several ways in which it could be done. "His plan," he asserts, "as then developed in conversation, embraced the essential and the peculiar features of the American telegraph, patented in 1840, by Prof. Morse. Dr. Jackson also declares that in the spring of 1834, he constructed and successfully worked, and exhibited to Francis Alger and other friends, a telegraph combining the peculiar features of that which he had invented on the steamer "Sully," though he did not think it

could be profitably brought into public use till the invention of the sustaining battery, in 1837, furnished the means of obtaining a long-continued voltaic current of uniform strength." *

The first practical test of the Morse telegraph was in 1835, when he exhibited one with half a mile of wire in a room in New York. In 1837, as said, he filed his caveat at Washington, and then went to Europe to patent his invention; but was refused one in every country to which he applied. At the time he filed his caveat, he asked Congress for an appropriation to assist him in constructing a line for a test. For four years he beseiged Congress in vain for assistance, and at the last moment, and when he had given up all hope, he was given an appropriation of thirty thousand dollars. With this amount, a line was constructed between Washington and Baltimore. "What hath God wrought!" were the first words sent over the line; and then the success of Morse was assured. Whether or not he was the inventor of the electro-magnetic telegraph, it is certain that he has received the widest recognition. Yale College gave him the degree of LL. D.; the sultan of Turkey gave him a decoration set with precious stones; by the French he was presented with the cross of the legion of honor; he was made a knight commander by Denmark; a knight commander of the first class by the queen of Spain; from Italy, he was the recipient of the cross of the order of Saints Maurice and Lazarus; and of another cross from Portugal. He was banqueted by the telegraph companies in Great Britain, by the Americans in Paris, and by the citizens of New York. In 1856, at the suggestion of the third Napoleon, there was a gathering of the representatives of France, Belgium,

* *Am. Cyclopædia.*

Holland, Russia, Sweden, Austria, Sardinia, Tuscany, the Holy See, and Turkey, at which it was voted to make him a present, which was carried out by a donation of the substantial sum of four hundred thousand francs. If these gifts and testimonials have any significance, it cannot but be that he is entitled to some credit in connection with the development of the electro-magnetic telegraph. It is said by his biographer, that he made the acquaintance of Daguerre while in Paris, and on his return constructed the proper apparatus, and took the first sun-pictures ever taken in the United States. In addition to his other labors, he was a quite voluminous writer.

In the development of his idea of the telegraph, Prof. Morse was assisted by L. D. Gale, and George and Alfred Vail. At first he had another form of recording than that of dots and dashes, which has since become so famous. His apparatus was always a recording one, but at the outset, it had none of the celerity which it possessed when the dot-and-dash method of recording was perfected. In the original it was so arranged that a continuous mark was made on paper, and variations from a straight line gave opportunity for a combination of signals. Thus, two vertical marks meant the numeral 2; three variations, 3; and so on through the numerals. This constituted a cipher, which was read by reference to an agreed-on code, of which the dictionary was the base. Now, the familiar dots and dashes are used sometimes with a paper on which they are graved by a steel pointer connected with an armature; but more generally, they are recognized by the ear. After long experience in reading the dots and dashes, the operator would begin to recognize each letter by a certain sound; in time, the marks on the paper would become gradually less and less noticed, and the ear would become more

and more expert in detecting the letter by the sound. At the present time, the number of operators who depend on the printed ribbon for the deciphering of the message is very small; that is to say, in this country. In the government telegraphic offices of Great Britain, the Morse recorder is in general use, and in the majority of cases a message is taken off the printed slip. On the railways in England, the needle telegraph is largely used. It does not record the message; it delivers its communication in the right and left variations of the needle. One can see that an alphabet can be very easily constructed from these deflections. Thus, two deflections to the left, the one following closely on the other, might be agreed on as meaning the letter "a"; three following closely, as "b," and so on through the alphabet and the numerals.

There have not been any noted inventions in connection with the transmission of correspondence since the Morse system was established; that is to say, anything strikingly new in the matter of instruments of transmission. Alexander Bain introduced the automatic process, in which a narrow strip of paper is punched in lines and dots, and this perforated strip is run at great speed over a roller, and is taken off by a receiving machine, running at the same speed as the sending machine, in dots and dashes. The rapidity of this machine is something marvellous; from five to six thousand letters a minute being transmitted. One of its great advantages is exhibited in cases where a message from a central point is to be taken off at several places along the line, as in cases of despatches for an association of newspapers receiving its news from a given point.

The fac-simile telegraph is a very curious and ingenious instrument. It is claimed as the invention of an Englishman, F. C. Bakewell, in 1850. A cylinder at one

station is duplicated in every particular at another station. The message to be duplicated in fac-simile, is written on tin-foil with varnish, and then is laid on one of the cylinders. At the receiving station, the cylinder is covered with a chemically-prepared paper, and has a pointer. Both cylinders are then set in motion; the pointer, as it touches the chemical paper leaves a red line, but when the metal pointer at the other end is lifted from the tin-foil by the varnish, the pointer at the receiving station ceases to mark. The result is that the outlines of the varnish are left in a blank space on the receiving paper. As the pointers move about the cylinder, they advance in a slow spiral, of which about ten lines are required for one line of writing. This was the manner in which the original fac-simile telegraph was operated; but there have been some substantial improvements. In France, more than in any other country, this form of telegraph is used; and is now so improved that the fac-simile is produced in black on a white ground.

The printing telegraph was one in very general use, but has been superseded by the telephone. There were several kinds, among which may be mentioned the House, and the Hughes; the Phelps, a combination of the better qualities of the two just mentioned; the Anders, and perhaps some others. The dial telegraph was for a time very popular; it was the one in which a needle pointed to the letters as desired by the operator. Unlike the others, it did not record the messages sent. In this country the dial telegraph, before the completion of the telephone, was in extensive use, and was operated by a small battery. In England they are used so as to be worked from the electricity generated by magnets. The generating of the electricity is an easy matter, it being done by treadles which set in motion the armature around the poles of the magnet.

CHAPTER XXVII.

ELECTRICITY AND ITS APPLIANCES.—CONTINUED.

FOR some little time prior to the introduction of the telephone, the district telegraph had a very large popularity; in fact, it is not yet disused, although largely merged into the telephone system. It consists of a dial fastened on the wall of the subscriber, and on which are lettered indications such as "Messenger," "Policeman," "Fire," "Carriage," "Doctor," and the like. A wire connects this with the district office. Upon turning the pointer on the dial to any one of the wants lettered on the margin, and pulling a lever, a connection is established with the central office, and the particular want, and the place from whence the demand comes, are indicated, and the necessary action at once taken.

There are many burglar alarms, which are simply forms of telegraphing. They are so constructed that the opening of a door or a window, or tampering with a safe, will establish a circuit which sets a bell to ringing, and thus alarms the inmates of the house.

A very ingenious telegraph is that which communicates the fact that there is a fire in a certain locality. In each room of a building in which this form of telegraph is used, there is placed in the wall or ceiling, a little cup of mercury. In case the heat of the room passes above a certain number of degrees, the mercury rises until it touches the ends of two wires; a circuit is

thus completed, and there is an alarm given, which is sometimes carried to a fire-station, where the number of the building is signaled. On the side of the houses thus guarded, there is usually a square iron box, within which is a dial noting the floors of the building. When the circuit is completed by the rise of the mercury, the pointers connected with the dials in the street-box indicate the floor in which the disturbance is occurring.

Prof. J. P. Barrett, the electrician of the city of Chicago, in 1879 invented an adjunct to the police and fire system—more especially the former—which is at once very ingenious, and of the greatest utility. It consists of a series of what are termed "patrol-boxes" placed at various parts of the city; say one, two, or even three for each block, according to the character of the various localities. These boxes have wires which connect them with the nearest police station. In case of the occurrence of anything demanding the interference of the police, the box is opened, and an alarm given by the pulling of a lever. This signals to the station an alarm, and the number of the box. A horse which is kept constantly harnessed to a "patrol wagon," accompanied by three policemen, is instantly started on a gallop for the box, reaching there always within a minute after the alarm is sounded. There is a further use in the box; there is in it a telephone, through which the policemen on patrol duty are obliged to report at stated intervals. The time is taken at the station, and thus it is always known whether or not the patrolman is at his post.

The same ingenious electrician has devised another thing which is of the greatest possible utility in signaling the existence of a fire in any part of a city. As the fire-alarms of the larger towns were arranged, before the invention of Prof. Barrett, the process of signaling was

a comparatively slow one. In signaling an alarm from any one of the street-boxes, the number of the box was sent to the central station. From this point, it was telegraphed to the various fire-engine stations. Suppose that the point from whence the signal was sent is 895. Twenty seconds would be consumed in the announcement to the central station; then the operator would cross to another part of the room, and adjust his dials so as to send the number to the sub-stations, at which it would be received in the shape of blows on a gong. Eight blows would first be struck, then an interval of five seconds; then nine blows, another interval, and lastly five blows. Here we have sixty-seven seconds from the time of pulling of the street-box till the alarm reaches the engines. Sometimes the men at the engine-houses would not be certain as to the numbers, and would wait for the second announcement. Fifteen seconds would elapse before the second alarm would be struck, and then forty-seven seconds would be required to strike the 895; that is, seventeen seconds for the 8, twenty seconds for the 9, and ten seconds for the 5, with an additional interval of five seconds between the 8 and 9, and another five seconds between the 9 and 5. Thus it might occur that there would be a total interval of one hundred and twenty-nine seconds between the time when the alarm would be first struck and that when the engines had become satisfied as to the location of the fire. Under this system, there would be no record of the alarm at the engine-houses, from which it would sometimes appear that the engine would be late in reaching the fire, and would urge as an excuse that the first alarm was not understood, and that the second notification had to be waited for. The invention of Prof. Barrett is what is not very elegantly termed the "little joker." It is a registering fillet of paper, enclosed

in a glass case at each engine-house. The instant a street box is "pulled" the number is sent in dashes not only to the central station, but to every engine-house in the city. The notification is substantially instantaneous, and at the same instant the electric current loosens the chains which hold the horses in the stalls. There is no delay whatever. The men cannot claim that they had to wait for a second notification; the call is recorded on the fillet, and as the glass enclosure cannot be opened without detection, the record remains to show for itself. The invention of this little instrument saves from one to two minutes in the time of getting to a fire; a gain of great importance in its early stages.

There are innumerable minor uses to which electricity is applied. One of the most common is for ringing bells from the various rooms of a house, or a hotel. There is now scarcely a first-class hotel in the country that is without its annunciator. There are electric clocks invented by Wheatstone, in 1840; there is an electric log used on vessels; tin-foil traced with patterns in varnish takes the place of the perforated paper in the Jacquard loom, and which, by the opening and closing of circuits, as metallic teeth touch the tin-foil and the varnish, perform all the work of the original invention—an electric loom invented in 1852 by Bonelli, of Italy; there are pianos operated by electricity, and which can be played by a performer in another town; there are railway signals which are moved by electricity, and which vastly increase the safety of railway travel; it furnishes in the electrophorus a convenient and certain gas-lighter; it, in the chronograph, records time and occurrences; it aids in etching by biting-in an engraving; it plays an important part in the treatment and cure of human maladies; it plates metals; it prints; it

engraves; it explodes the charge in the harpoon; it acts as the governing-power of machinery in stimulating laggard motion, and in restraining that which is too rapid; it fires the charge which is laid in the mountain-side, or beneath the ocean; it furnishes light, the power for moving vehicles, the light at the mast-head of a ship; the warning-blaze in the light-house, and the gentle radiance which lights the salon, and the theatre; in fine, it is omnipresent, indispensable, and almost omnipotent.

Its character as a news-bearer has been in part given in the description of the electro-magnetic telegraph. There is one phase of this department of electric effort which deserves some special attention. It is that connected with the submarine cable.

To whom the credit of the first submarine cable is due is not clearly known. There is said to have been a suggestion of one near the close of the last century; but the condition of electrical knowledge was such at that time, that there is little reason for believing that there could have been a scheme of value developed at that early period. It is said that some experiments were made in India, in 1839; and a year later, Wheatstone gave it as his opinion, in an official enquiry, that a wire could be laid between England and France. Morse and Colt both laid wires under water, the first in 1842, and the other, in 1843. Lieutenant Siemens, brother of the well-known Siemens in England, laid what is claimed to be the first submarine cable, across the Rhine at Cologne, a distance of half a mile. The first one of any consequence was one laid from Dover to Calais, in 1850. It was a single wire, covered with gutta percha; the year following, it was replaced by a cable of four wires, and proved a permanent success. Up to 1857, not more than a thousand miles of submarine lines had been made; and then an effort was made to lay one beneath the Atlantic

for the purpose of connecting the United States and England. The genius to whom we are indebted for the conception, and for the attempt, as well as for its success, was an American, Cyrus W. Field.

This gentleman was born in Stockbridge, Massachusetts, in November, 1819. He commenced life as a merchant, in which he continued until he grew wealthy, and from which he retired in 1853. During his travels, he became impressed with the idea of the value and feasibility of a cable beneath the ocean. For several years, he spent his time and his money unsparingly in his effort to carry his idea into practical effect. A less resolute man, or a man of the average endurance, would have yielded to what seemed the impossible, before he had traversed one-third of the distance which was covered by Field before success was attained. He succeeded in enlisting the sympathy and the capital of some men in New York, in aid of the enterprise; and thenceforward gave himself up to the labor which he had in view. Among those who were enlisted by him were men well-known throughout the country, among them being the late Peter Cooper, Marshall O. Roberts, Moses Taylor, and others.

In 1855, he had completed a land line of some four hundred miles across Newfoundland, and then went to England, and had constructed cable sufficient to extend from Cape Ray to Cape Breton. It was lost in an attempt to lay it across the St. Lawrence. The next year, he ordered in London a sufficient length of cable to cross the Atlantic. When completed, he made three attempts to lay it. The first, in 1857, failed, and so with the second, the next year. The third attempt, in 1858, was a success, but only for a short period; and then the cable, after responding for a month or so, became suddenly and permanently silent. The loss of three cables discouraged

everybody connected with it except Field; he kept up his courage, and would have sooner re-attempted the enterprise except for the breaking out of the civil war in the United States. It was not till 1865, that he renewed the attempt, and then under more favorable circumstances. The "Great Eastern" had been built, tried, and proved a failure as a passenger ship; she was employed by the cable company, and for the first time in her career, it became apparent as to what she was fitted for. There had been an improvement, in the meanwhile, in the construction of cables; and success seemed this time to be within reach. At the distance of something over a thousand miles, the cable snapped, and the fourth attempt was a failure. Who would not, at this period, have given up the effort as an impossible one? Field did not. He tried it again in 1866, and this time the cable was landed, and was a success from the beginning. Then the "Great Eastern" returned to mid-ocean, and after a long search, grappled with the lost cable, spliced it, and returned to America. The results accomplished by Cyrus W. Field, from their inception to their success, have few parallels in history. There have been several cables laid since, between the old and the new worlds, but in none of them has there been a tithe of the difficulty which was experienced by Field in getting the first successful one into place.

At the present time, there are more than fifty-five thousand miles of submarine cables in use, and seven hundred and fifty thousand miles of land wire, of which this country has more than any other. The time is probably not distant when the Pacific will be crossed, and the circuit of the world will be completed.

A most important development of the uses of electricity is in the telephone, which, a few years ago, a mere curiosity, a scientific toy, has become an indispensable

part of our civilization. It has almost wholly driven the once-industrious district messenger system out of existence, and is very rapidly, within certain limits, supplanting the telegraph.

In principle, the telephone is very old; for, in fact, anything is a telephone which conveys a sound to a distance as a means of communicated ideas. A steam-whistle which announces the approach of a train is a telephone in every sense of the word, as much so as the latest improvement of the Bell-Edison combination. The knowledge that sounds could be carried to a distance by the use of a wire, a string, or some other conductor, is no new thing; but that electricity could be used as an adjunct in the transmission, is a late discovery. The germ of the discovery of the electro-magnetic telephone was in the result of some investigations made in 1837, by Prof. Charles G. Page, of Washington. He found that the rapid magnetization and demagnetization of a magnetic bar would produce sounds, and that the sounds corresponded with the number of currents which produced them. Although there was much speculation over this discovery, nothing came of it until, in 1854, when Charles Bourseul, a Frenchman, published an article in which he announced his conviction that the transmission of speech by electricity was entirely a practicable fact.

In this paper, Bourseul said: "We know that sounds are made by vibrations, and are adapted to the ear by the same vibrations which are reproduced by the intervening medium. But the intensity of the vibrations diminishes very rapidly with the distance; so that it is, even with the aid of speaking-tubes and trumpets, impossible to exceed somewhat narrow limits. Suppose that a man speaks near a movable disk, sufficiently flexible to lose none of the vibrations of the voice, that

this disk alternately makes and breaks the currents from a battery; you may have at a distance another disk, which will simultaneously execute the same vibrations.

"It is true that the intensity of the sounds produced will be variable at the point of departure, at which the disk vibrates by means of the voice, and constant at the point of arrival, where it vibrates by means of electricity; but it has been shown that this does not change the sounds. It is, moreover, evident that the sounds will be produced at the same pitch. . . .

" . . . Observe that the syllables can only reproduce on the sense of hearing the vibrations of the intervening medium; reproduce precisely these vibrations, and you will reproduce precisely these syllables. It is, at all events, impossible, in the present condition of science, to prove the impossibility of transmitting sound by electricity. Everything tends to prove, on the contrary, that there is such a possibility. When the application of electro-magnetism to the transmission of messages was first discussed, a man of great scientific attainments treated the idea as Utopian, and yet there is now a direct communication between London and Vienna by means of a simple wire. Men declared it impossible, but so it is.

"It need not be said that numerous applications of the hightest importance will immediately arise for the transmission of speech by electricity. Any one who is not deaf and dumb may use this mode of transmission, which would require no apparatus except an electric battery, two vibrating disks, and a wire. In many cases, as for example in large establishments, orders might be transmitted in this way, although transmission by electricity will not be used while it is necessary to go from letter to letter, and to make use of telegraphs which

require use and apprenticeship. However this may be, it is certain that, in a more or less distant future, speech will be transmitted by electricity. I have made some experiments in this direction; they are delicate and demand time and patience, but the approximations obtained promise a favorable result." *

This was written in 1854, and at this day, in view of what has been realized, it sounds more like a prophecy than the mere speculations of a man of science. The modern telephone is to-day what he then described it, as exactly as if he had had one of the latest of the improved telephones before him. For twenty-two years the telephone remained where it was left by Bourseul. That Bourseul has priority in the conception of the telephone, there can be no doubt; as to who is entitled to the credit of the instrument itself there is considerable discrepancy of opinion. On the 14th of February, 1876, Elisha Gray and Alexander Graham Bell, of Boston, deposited in the patent office in Washington, the former a caveat, and the latter an application for a patent for an instrument of the same kind, but with some modifications. Before specifying the differences in the two applications, it may be added that there is authority for the statement that before this time, in the year 1861, Philip Reis, a German, availing himself of the discoveries of Prof. Page, in regard to the sounds produced by the rapid magnetization and demagnetization of a magnetic bar, had constructed a telephone in which a vibrating diaphragm was caused to make and break a galvanic circuit. "Reis' apparatus reproduced the tone or pitch of sound, so that the successive notes of a melody could be distinctly recognized; but they were all of the same intensity, because the currents which formed them

* Count du Moncel.

were all of the same strength. It was, therefore, only a philosophical toy, and therefore of no value." *

In 1873, Prof. Gray produced an instrument for the conveyance of musical tones, and which he did to the great delight of crowded audiences in Chicago, and perhaps in other places. John Camack, an Englishman, claims to have discovered the telephone in 1865; but he did not get beyond the drawings, for the reason that he had no means of carrying it into practical shape. An Italian named Manzetti, claims that he described in several newspapers, in 1865, a telephone; but there seems to have been nothing in his assertion that permits the conclusion that his suggestion would have reached the end sought and obtained by Bell, Gray, Edison, and the others.

In regard to the claim as to priority of Bell and Gray, it is not within the intent of this volume to settle or even to comment on controverted points. It will answer all present purposes to state that the matter has been passed on by experts, and that the verdict of the civilized world has been in favor of Prof. Bell. There is, however, opportunity for an argument against this conclusion; for there are those who are firm in the opinion that Mr. Gray is the one to whom should be assigned the verdict and the honors of the controversy.

Elisha Gray, however, is not without a history, and one that will do him honor. He was born in 1836, in Barnesville, Ohio, where he learned the trade of blacksmithing, and later, that of a carpenter and boat-builder. After having completed his apprenticeship, he resolved to study, which he did at Oberlin, supporting himself by working at his trades between the terms. He was interested in electricity at a very early age, whose results

* *Am. Cyclopædia.*

were that, later in life, he was able to place many inventions and improvements before the public, all of which have reference to electrical appliances. He did invent a telephone for speaking, but his first production appears to have been, not a speaking telephone, but a musical one—an electric harmonica. In his own account of the invention of the musical telephone, he says that the idea was suggested by an incident which occurred in his bath-room, in which he found his nephew playing with an induction coil. One end of the coil was connected to the zinc lining of bath-tub, the other end was held in his left hand, while with the right, he touched the zinc lining, moving his hand at the time along the surface. As he did so a sound was produced at the point of contact; this excited the attention of Gray, and an investigation followed, whose result was the musical telephone, and later, the speaking telephone. It does not militate against his statement that his idea was not a new one in the world of science; it may have been an entirely original one with him. Some years even before the suggestion of conveying sound by electricity occurred to him, in 1860, the Reiss telephone was in existence for the transmission of melodious sounds. It was not as complete as Gray's and later instruments. Count du Moncel, long before either the production of the Gray, or even the Reiss' musical telephone, suggested that electro-magnetism would come to the aid of certain instruments, such as pianos, organs, etc., in order to enable them to be played at a distance.

Mr. Gray has taken out in all some fifty or sixty patents, among others for multiplex telegraphy, or the transmission of more than one message at a time on a single wire, and which has since been so improved that now eight messages are sent along a wire at one time, each being taken off at the receiving point without the

slightest confusion. The principle, in his own words, "is based upon the ability to transmit a number of tones simultaneously over the same wire and analyze them at the receiving end, so that each tone will be audible on a particular instrument which is tuned to it, but to no other. He was engaged in the manufacture of telegraphic apparatus, and was for a time the electrician of the Western Union Telegraph Company. His latest telephone was a speaking one, and obtained for a time a wide use. It will be remembered as the one in which the two mouth-pieces were side by side.

The Bell telephone was constructed in 1876, and exhibited the same year at the Centennial in Philadelphia, where it excited the greatest attention, and was the theme of universal comment. As compared with the telephone of to-day, it was as a muttered whisper to the clear, distinct tones of a speaker in a public hall. The writer, in 1878, talked and heard through it, and talked with Prof. Bell through a line of a quarter of a mile in length. Even then, although two years old, it was with the greatest difficulty that a communication could be heard for the short distance it had to traverse; but even in this condition, it was readily taken hold of by the English, more especially for use in the mines. The fact that, in such an imperfect condition, it could excite a most enthusiastic support proves how valuable was the use to which it was devoted. To-day, it is far from being the same whispering, muttering, gurgling instrument. It has united its forces with the Edison instrument, under the name and title of the "Bell-Edison," and may be heard for miles, conveying a voice with all the distinctness that does the air of a room through a distance of ten feet, and retaining all the peculiarities of the tones of the speaker. The invention of the Bell instrument was the first which transmitted, so to speak,

all of a voice; it was the first, in its improved state, to preserve all the qualities of the sound which it dealt with.

The Dolbear telephone presents another case of what may be simultaneous conception; he constructed a telephone about the same time as Bell, and which was very much like that of Bell. There has been, and is still, an enormous variety of telephones in use, but unquestionably the most valued is the united Bell-Edison instrument, in which are believed to be combined the very highest results of telephonic improvements. And this suggests some special mention of one of the most remarkable men of modern times, in connection with discoveries of applications of electricity.

Thomas A. Edison, like Elisha Gray, is an Ohioan, having been born in Milan, February 11, 1845. He is thus not yet forty years of age, and has already obtained a fame as an inventor that is without a parallel. He, too, was of humble birth, and received such schooling as he had from his mother. He commenced life as a train-boy on the Grand Trunk railway when he was but twelve years of age. His earliest noticed development was in the direction of electrical appliances, which he examined, and studied as he could from the operations of the telegraphic lines and stations along the road. He was finally taught telegraphing by an operator whose child's life he had saved, and in this way began his march as an electrician. After he had learned operating thoroughly, he wandered for a time over this country and Canada, living by the wages of an operator, but meanwhile keeping up his studies and experiments in electrical directions.

In 1868, he had reached Boston in his wanderings, and there brought out several inventions, one of which was duplex telegraphy, but which proved a failure, and

induced him to leave for New York. There he suggested the printing telegraph for stock and gold quotations, and at once was retained by the gold and stock company and a telegraph company, at a high salary, for which he was to do what he pleased in the line of experiment and investigation, and to give them the refusal of his improvements. In 1876, he removed to the now famous Menlo Park, in New Jersey, a short distance from New York City, in order that he might carry out his investigations without interruption. There he fitted up large workshops for the manufacture of electrical apparatus, and the practical development of his conceptions.

From that date to this, the name of Edison has been a household world. For years he kept the two worlds in a state of constant wonderment and expectation. His achievements were so wondrous that he seemed to be possessed of supernatural power. His carbon telephone brought the telephone of Bell and others from an instrument with little power and small value, to one of the greatest importance; it changed in an hour, a weak-voiced, stuttering, piping infant into a man—deep-chested, powerful as to voice, and energetic as to action. But of all the inventions, although as yet, the least in value, which he has given to the world, the phonograph attracted the most attention, the most undiluted amazement. He was not the originator of the idea. It is, however, an improvement on all which preceded it, as much so as a Whitworth gun is an advance beyond the rude cannon which soon followed the introduction of gunpowder. In 1856, Leo Scott invented an instrument which is known as the phonautograph, which is so arranged as to record the impulses of the air made from the mouth in uttering articulate sounds. In this, as in the phonograph, there is a membrane against which the voice (so to speak) strikes, and agitates the membrane;

there is a delicate marker connected with the membrane which vibrates as the membrane is agitated, and these agitations are traced by the marker on a traveling-ribbon. At the very most, this can be called but a method of registering speech; and there does not seem to be any certainty that what was thus written could be deciphered. It resembled a series of mountain peaks, and the intervening hollows; with here and there peaks shooting suddenly high in the air, and dropping as suddenly down some sharp declivity. These elevations and depressions correspond to the force, duration, and other qualities of the tone.

There is little similarity between this phonautograph of Leon Scott, and the phonograph of Edison. Both are speech recorders, but here the likeness ends; for, by the recording instrument of the latter, the words recorded can be again turned into sound, and be re-delivered in the same words, and quality of voice with which they were given to the keeping of the machine. It may be that the re-transmission of the words might have been accomplished by the Scott machine; but if so, it does not seem to have been thought of. It remained for the genius of Edison to produce this marvellous result. The principle of the registration is the same, except that in the case of the Scott instrument, there is no apparent use to be made of the results save as a curiosity. Edison may have availed himself of such advantages as were to be found in the instrument of Scott; but it is claimed that the suggestion of the phonograph came to him by accident. They say that one day, when engaged in testing a telephone, the stylus attached to the vibrating membrane pricked his finger, and drew blood, the vibration being caused by the action of the voice, whereupon it occurred to him that if the stylus, under the influence of the voice, had sufficient force to prick the skin, it

would have enough force so as to produce on a flexible surface lines which would represent all the undulations of the voice. At the same time, came the suggestion that "the same outlines might mechanically reproduce the vibrations which had caused them, by reacting on a plate capable of vibrating in the same way as that which he had already used for the reproduction of the Morse signals."

Everybody knows the workings of the phonograph, but its outlines may be briefly sketched. There is a cylinder, which may be of any desired length, but say twelve inches. Around this, beginning at one end and extending to the other, in a close spiral, a light groove is cut. Over this cylinder there is placed a covering of tin-foil. There is a mouth-piece, as in the telephone, which has a vibrating membrane like the tympanum of the ear; to the other side of this membrane, there is a light metal point, or stylus, which touches the tin-foil just over the groove. A forward motion is given the cylinder by a crank, and an axle that is a screw, and meanwhile the operator talks into the mouth-piece. Of course, the membrane vibrates under the impulses of the voice, and the stylus marks the tin-foil in a manner which corresponds to the varying vibrations of the membrane. When the speaking into the mouth-piece is completed, the stylus and mouth-piece are set back to the point whence they started. If now the screw be turned at the same rate of speed as at the first, the stylus will pass in and out the marks made in its first passage, and in doing this will produce the same vibrations in the membrane that it underwent when the marks were made. These vibrations will affect the air, and this again the ear of the listener, who will hear repeated the same precise words which were "talked into" the instrument.

If, after the tin-foil has recorded what has been

spoken, the covering be removed carefully, and laid away where it will not be disturbed, it can be replaced on the cylinder at any time, and the spoken words be reproduced as they were uttered.

March 11, 1878, Mr. Edison exhibited his phonograph before the Academy of Sciences in Paris. The account of the exhibition is quite curious, and will bear reproduction: "When his agent, Mr. Puskas, caused the wonderful instrument to speak, a murmur of admiration was heard from all parts of the hall—a murmur succeeded by repeated applause. A letter appeared in the newspapers from one of the persons present in which he said that the learned academy, generally so cold, had never before abandoned itself to such enthusiasm. Yet some members of a sceptical turn of mind, instead of examining the physical fact, ascribed it to moral causes, and a report soon ran through the room which seemed to accuse the academy of having been mystified by a clever ventriloquist. Certainly the spirit of ancient Gaul is still to be found among the French, and even in the academy. One said that the sounds emitted by the instrument were precisely those of a ventriloquist. Another asked if the movements of Puskas' face and lips as he turned the instrument did not resemble the grimaces of a ventriloquist? A third admitted that the phonograph might emit sounds, but believed that it was much helped by the manipulator. Finally, the academy requested Du Moncel to try the experiment, and as he was not accustomed to speak into the instrument, it was unsuccessful, to the great joy of the incredulous. Some members of the academy, however, desirous of ascertaining the real nature of the effects, begged Puskas to repeat the experiments in the secretary's office under such conditions as they should lay down. The agent complied with the request, and they were

absolutely satisfied with the result. Yet others remained incredulous, and it was necessary that they should make the experiment for themselves before they accepted the fact that speech could be reproduced in so simple a way." *

One of the peculiarities of the phonograph is that a series of sentences may be registered, over this another, and still another over the two; they may all three be in different languages; one of them may be a spoken communication, another may be vocal or instrumental music; and yet when the movement is made for reproducing what has been said, sung, or played, each comes out with a distinctness which can be recognized. It is a wonderfully capable machine; it can talk in three languages all at the same moment, or can talk and sing at the same time without the smallest confusion. What may be the mission of this instrument in the future is not known; at present it is little more than a curious toy. The time may come when by some process the words of an orator or the song of a prima donna, may be taken; or the last words of the victim of a murderer may be recorded, and all preserved in metal to be used when occasion demands.

Edison gave to the world the improved benefits of sextuplex telegraphy, the microtasimeter, the aërophone, the megaphone, the phonometer, the electric light by the incandescence of a carbon loop in a vacuum, the electric pen, and a host of other inventions. The megaphone is a combination of the ear-trumpet and the speaking trumpet, by which very light sounds can be heard at a great distance, and by which persons can converse over a distance of a mile. The aërophone is a device for bringing steam to the aid of the human voice.

* Count Du Moncel.

so that its penetrating power may be increased a great number of times, the purpose being to enable converse between ships at sea when a great distance apart. The microtasimeter is an exceedingly delicate instrument for measuring variations in temperature, and incidentally variations in bodies, the most infinitesimal change being noted and recorded by this invention.

That Edison is the inventor of multiple telegraphy cannot be justly claimed; he may have improved its processes; but the credit is due to others, at least for the conception. As long ago as 1854, Starke devised a method of sending two messages at the same time on the same wire. Both Siemens and Halske, independently of each other, in the same year, 1854, discovered a method of sending two messages at the same time in opposite directions. What Edison did was to improve on the processes already in use. It is claimed his method is wholly original; in the words of his biographer, "The method invented by Starke in 1855, and improved by Kraemer, Bernstein, Schreder, and other German electricians, consisted in employing a number of relays, and was only practicable on short lines. Proceeding by entirely original methods, Edison confined himself to two relays, avoiding by an ingenious device the obliteration of signals caused by changing the polarity of the current. By the contrivance of the electric-motograph, the most sensitive recording instrument ever invented, Edison gave to the world the duplex system of telegraphy in a working shape, and rendered quadruplex, and sextuplex transmission possible." *

One of the greatest of the inventions of Edison was that by which electric incandescence has become of practical utility. He is not the inventor of the principle

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* *Am. Cyclopædia.*

of incandescent light; but he is the one who has developed the principle into a practical form, and has given the world a lamp which can be used for substantially all illuminating purposes. In 1845, E. A. King, of London, introduced a lamp, in which the strip of platinum was brought to incandescence by a current of electricity. In 1849, another experimenter named Petrie substituted iridium for platinum. In 1873, a Russian named Lodyguine produced a lamp in which the material to be illuminated was carbon. He inclosed the carbon in a glass vessel which was hermetically sealed, and from which the air had been exhausted; but he could not succeed in prolonging the life of the carbon above a few hours. In 1875, Kohn, also of St. Petersburg, tried to remedy the fault of the other by the use of carbons, side by side, and so arranged, that as fast as one was exhausted, another would take its place, and by this means, secured a fair success.

The incandescent light which was brought out by Edison involves no new principles; what he was so long in search for was some material that could be made into suitable carbon, and a process by which the glass globes containing the carbon could be made into a complete vacuum. The latter was accomplished by the use of a mercury pump, and the heat of electricity, to an extent which left in the globe but a little more than the millionth of an atmosphere. The material for the carbon was finally found in bamboo fibre; and now the incandescent lamp is in use in this country, and is pronounced a complete success. It is being rapidly introduced into hotels, theatres, public halls, and dwelling houses.

CHAPTER XXVIII.

ELECTRICITY AND ITS APPLIANCES—Continued.

THERE are various methods in use for the generation of electricity; and for the developments of these methods there is an almost endless variety of apparatuses. In the development of frictional electricity, there are two machines; one is of the kind in which a cylinder is used; and the other, one in which plate-glass is the object which sustains the friction—the former is the more convenient and the latter more powerful. The first plate machine was the invention of Charles Winter, of Vienna; the next of any consequence after this was made in Edinburgh, by Dr. Ferguson, in 1858. In this class of machines, the glass, being cut in circular form is revolved rapidly. Hard rubbers regulated by a screw, are pressed against the revolving plate, and the electricity generated is carried off by strips of tin-foil. In the cylinder machines, the cylinder is composed of glass, is turned rapidly, being touched by a rubber, and the electricity generated by the friction is taken off by a comb with pointed teeth.

Under the head of galvanic batteries, there is a large number for the production or development of electricity. In these batteries, the composition consists of a strip of zinc and one of copper, in a vessel in which there is water, into which has been poured a small quantity of sulphuric acid. So long as these plates are kept

separate there is no action; but if they be placed so as to touch, or are connected by a copper wire, there begins at once the evolution of electricity. A number of these jars placed side by side, and so arranged that the copper plate of one jar is connected by a wire with the zinc in next, and the outer copper-plate of the first jar or cell, is connected with the last copper plate of the last cell, a current is formed which runs from one jar to the other and passes around the wire back to the first cell. This current leaves the battery where the wire is connected with the copper plate, and enters the battery at the other end through the zinc plate in the first jar, thus forming what is termed a circuit, and which may be ten feet in length, or any number of miles. The jars thus connected form a battery.

The number of these chemical or galvanic batteries is very large. There is the Wollaston battery, which differs from the one just described in the particular that the copper plate is doubled up, and includes within it a plate of zinc. Daniell's battery is one which has a large use; the copper plate is united at the edges so as form a solid cylinder; within this is another cylinder of porous, unglazed earthen-ware, and within this is a rod of zinc. A solution of sulphate of copper is placed between the copper and the earthen-ware, and dilute sulphuric acid between the earthen-ware and the zinc. The Daniell's cell has several modifications which it is unnecessary to particularize. In addition there are the Grove, the Bunsen, the Leclanché, the gravity, and many others. In all these the effect produced is from the action of chemical fluids on materials such as copper, zinc, platinum and iron. There is also the thermo-electric battery, which is a machine for the evolving of electricity by the application of heat or cold to the junction of a circuit composed of two metals.

(74) DYNAMO ROOM—GENERATING ELECTRICITY. ([illegible])

The magneto-electric machines have of late assumed a great prominence, the more so as there is a growing demand for the electric light, which cannot be furnished from battery power, owing to its costliness.

Zinc is far more expensive than coal; hence the necessity of some more economical process of securing an electrical supply. Coal furnishes the heat which impels the steam-engine, and in this direction is the world looking for that supply of electric power which it so much needs. The steam-engine drives the magneto-electric machine, or the dynamo-electric machine, and from this we now get the power which furnishes the electric light, and supplies the motor for the propulsion of vehicles, and other mechanical labors. In all these, the principle involved is that currents of electricity are brought into existence by the rapid revolution of an armature between the opposite holes of a horse-shoe magnet. In some of these, the current is continuous, in others it is an alternating one. The most noted of the machines of the kind in use are the Clarke, the Wilde, the Gramme, and the Edison. There are perhaps scores of these machines, all substantially the same in principle, but which employ varying devices to obtain the same end. Thus far the principal use of this class of machines has been for the supply of the arc and incandescent light, and in a few instances for the driving of cars, as is done in London by Siemens' experimental electric railway line, and in Berlin for the transportation of passengers.

The sudden development of the magneto-electric machines has been one of the highest importance, for it is leading to the solution of the question of illumination, and the furnishing a substitute for steam as a motor.

One of the triumphs which this class of machines has

furnished, is that connected with illumination. Until they were invented there was no adequate illumination for scores of places. There was no such thing as efficient street-lighting; the comparatively insignificant jets of light in the light-house did not at all answer the end which they should. The world was too dependent on the moon and stars at night; we were left at the mercy of expensive, and often times offensive gas; the sleeping-rooms are yet too often redolent of the stifling vapors of kerosene; the great cities are full of ambuscades hollowed out in the darkness in which assassination lurks, and the robber awaits his victim. The intellectual brightness of the age has found no corresponding illumination of terrestrial night. That there will soon be something approaching an equality between the two seems assured.

The arc light which is now in so general use for the illumination of streets and large buildings, is a very simple affair in its principle. Two sticks of carbon are arranged so that their points touch, or nearly so; a stream of electricity is sent through them; and as it passes from one to the other, produces intense heating and volatilization of the carbon points, and thus creates the intense glow which is seen at the point of junction. The differences of the lamps are in minor details. One of the main differences is to be found in the methods of so controlling the sticks of carbon that, as they are eaten away by the currents, they shall always preserve the same distance from each other at their points. Herein has been exhibited an immense amount of investigation. In the main, it is the variation in the length of the arc which causes the "flickering" in the light. If the carbons are just the proper distance apart, the light remains substantially continuous and equal; but if the approach of the carbons towards each other

be spasmodic, there is a marked variation in the flow of the current. There are various devices to secure this equal advance of the carbons, and this constitutes the main difference in the various kinds of "lights" before the public. In what is known as the Jablochoff lamp there is a difference in the arrangement of the carbons; they are arranged side by side, separated by some non-conducting materials. The current passes from the end of one to the other of these perpendicular carbons, the light being made at the point where the electric flow passes from the one to the other. As, in the ordinary lamp, the positive carbon is consumed twice as fast as the negative one, there would result in the Jablochoff system, that the two carbons would soon become uneven were it not that the current is alternated and sent once through the positive, and then through the negative carbon. The principal lamps for the use of the arc light are the Brush, Rapief, Werdermann, Wallace, and Jablochoff.

The Brush light made an excellent record as to economy in London, in 1880, where, in competition against two other lights, it carried off all the honors. It not only gave a better light than the others, but at less cost. The test was a very thorough one, involving a considerable portion of the river between Charing Cross and the Cannon Street Bridge, the vacant space west of the Exchange, and some distance along Cheapside. The American competitor could light a given space for less than one-half the cost of the lowest of the others.

The use of electro-motors is a matter which is now attracting a vast amount of study, investigation and expectation. The present dynamo-machines can all be used as motors, and electro-magnet machines can be constructed at no great cost. So long as the consumption of zinc was the cost of energizing an electro-motor, it

THE BRUSH ELECTRIC LIGHT—STREET ILLUMINATION IN NEW YORK. (538

was useless to attempt its construction; but now that coal has entered the field as a competitor, the question of expense is eliminated. It is quite within the limits of the possible that, in the next five years, electricity will be found as common as steam for the driving of machinery. Not only will it be the motor for tramways, and perhaps all forms of intramural vehicles of transportation, but it will extend its utility to a thousand forms of machinery which are now run by water, steam, or horse-power.

Much speculation has been indulged in upon the possibility and feasibility of utilizing the power of water-falls for the driving of dynamo-machines, whose currents will be conducted by wires and used at points where power is desirable, and none to be had. The first expressed public opinion as to this was given in 1872, by Prof. Blyth, who said, "magneto-electric machines might be employed to utilize the water-power at present running to waste, of mountain torrents, by first employing these torrents to generate current electricity by means of magneto-electric machines, and then transmitting the currents by means of wires to drive an electro-magnetic machine wherever wanted." Sir William Armstrong and Dr. Siemens have both given this suggestion a practical solution by using water-power to transmit electric power for the driving of saw-mills, and for several other useful purposes.

There are dreamers in this country who have often cast an enquiring eye at Niagara Falls, as if to measure its capabilities for usefulness. Here is enough power going to absolute waste, which is perhaps sufficient to drive all the mills in the union. It is not a power which would cost a dollar to put in use; to harness steam demands an immense expense in fuel; in this other case, no fuel is demanded. It would be as if all the

steam-engines could be furnished with steam ready made for use, and which would not involve the expenditure of a cent in preparation. Some day not distant, Niagara Falls will have another role given it; it will be no longer a romantic torrent, thundering and smoking as it leaps from the verge of the precipice into the tremendous depths below. This is the age of utility. All power is needed to employ the busy hands of labor, to increase the utility of materials, to enhance the value of production, to clear up the waste places in our industrial areas, and to make this the wealthiest, and the most powerful of all the nations. And to this end shall the roar of Niagara be blended in the great, harmonious song of labor.

The patent office reports will afford something as to the growth of the electrical science. In the year 1882, there were over two thousand applicants for patents in electricity, of which over two-thirds were granted. Five years ago, electricity was a sub-class in a division; now it has risen to the dignity of a division, and the largest and most important in the department. One of the examiners, in commenting on this astonishing growth, attributed it to two causes—the invention of the telephone, and the development of the magneto-electrical machine. He was of the opinion that there has been but little in the shape of invention within late years, but there has been a most wonderful growth in the application of known principles. "The present activity," he said, "springs from the application of well-known exhibitions of the still unknown force; and moreover, only a few of these features of the science have yet been made of practical value. One of the broadest and most successful patents appears to have been the telephone. The man whose name is perhaps more widely known than any other in connection with inventions, in his line of

investigation, is Edison. His most famous achievements have been in the improvement of telegraphy, and the incandescent light." *

Not only are the possibilities of the electrical science almost illimitable, but its practical uses are already enormously extended. Many of the uses of this potent and versatile energy have already been specified. There are still others whose mention would reach an indefinite extension. It enters into almost every department of the decorative and the useful. One of the uses to which it has lately been put is as an assistant of the photographer, by which instantaneous views can be obtained of any object. In this direction there has lately been taken a series of photographs which overthrow all previous notions in regard to the movement of a horse in a trot, gallop, or other gait. A large number of cameras are set side by side along a track which the horse is made to pass. An equal number of fine threads cross the track in front of the horse, which are broken as he strikes them, thereby bringing a current of electricity into action whereby the slide of the camera is raised for the briefest possible fraction of a second, with the result that the horse is taken in whatever position he may be, as if he were motionless. All painters have hitherto represented the horse at a gallop as if his fore and hind legs were in the air; the former pushed straight out level with the body, the latter extended in the same way to the rear. These instantaneous views have shown that a horse is never, under any circumstances, in any such position, and that the only time when he has all his legs off the ground is when they are doubled up under him.

One of the uses of electricity is for electro-plating,

* E. M. Bently.

gilding, and the like, in which gold, platinum, silver, copper, zinc, lead, cobalt, and nickel are applied as a permanent coating to some material. This use enters largely into the trades, such as in the case of Britannia-ware, and nickel-plated goods, which are so common in almost every part of the world. This plating is very simple in principle; the metal to be silvered is hung in an electric bath, and allowed to remain there till it is coated to the proper thickness.

Electrotyping is of the greatest possible consequence, more especially in printing. A mould of wax is made of the page of type or wood-cut to be copied, and is suspended in a bath of sulphate of copper and sulphuric acid. In a little time the mould is covered with a face of copper, which is exactly a reproduction of the face of the mould. This is taken off, and is backed by metal and wood until it is the height of the types in use in printing, and then is ready for the press. In this process the electricity for the work is usually furnished by a Daniell's battery, but since the improved magneto-machines, they are being largely used in the more extensive establishments, for the reason that the process is not only cheaper as to material used, but much more rapid.

In some of the processes of galvanizing iron, the plates to be tinned are so placed that a weak battery is formed, by whose action the tin is deposited on the iron. The galvanoglyph is a form of engraving in which an etched zinc plate is placed in an electro-bath, and a reverse is obtained from which printed impressions can be taken. There is a small magneto-electric machine which is much in use among medical men, in which a current of electricity is generated by the revolution of an armature at the poles of a couple of magnets.

What is known as the Faure battery, or "accumulator," is a late discovery which promises to be of great

value. It is not precisely a magazine for the confining of electricity, but it is a species of battery which may be charged, disconnected, carried for a considerable distance and then its electricity given out for whatever

THE BRUSH STORAGE BATTERY.

uses desired. With this so-called magazine, a house may be lighted, the magazine being charged daily and supplied to customers as are the magazines of soda-fountains; the empty ones being taken away to be refilled,

and full ones taking their places. This process of "storing electricity" will supply innumerable wants of a small kind, especially in localities where a small amount is wanted, and where it will be economy to erect machines for its production.

An outline of the principal facts in electricity would not be complete without some notice of Faraday, an eminent scientist, to whom the world owes a vast debt for his labors. Michael Faraday was born in Surrey, England, September, 1791, and died at Hampton Court, August, 1867. He was of humble parentage, his father being a blacksmith, without either health or wealth. Young Faraday had no educational advantages up to the time he was thirteen years of age; and then, for a time, such as he received was what he gathered while serving as an errand boy in the shop of a book-binder and bookseller in London, and after a year, as his apprentice. Here he had access to some scientific works, among the most attractive of which were articles in them which treated of electricity. He also managed once a week to hear a lecture on natural philosophy, the expense of which—one shilling a week—was defrayed by his brother; and at about the same period of his life he had the satisfaction of hearing four lectures by Sir Humphry Davy. As had been his wont, he made notes of Sir Humphry's lectures, which he soon afterwards extended in a form as full as he could, interspersed them with illustrations from his own pencil, and sent the whole to Sir Humphry "as a proof of my earnestness."

The result of his endeavor to convince the great scientist of his "earnestness" was a very satisfactory one. He called on Davy by invitation, and was at once made assistant in the laboratory of the Royal Institution, when he was twenty-two years of age. He soon after traveled abroad with Davy, for a year and a half,

acting as his amanuensis and assistant in experiments. Upon their return he resumed his place in the laboratory and delivered several series of lectures on chemical subjects before he was twenty-five. In 1818, he discovered that the phenomena of musical flames were not dependent "upon the sudden expansion and condensation of vapor," as had been supposed; but "that they were connected with musical vibrations produced in a manner similar to the tones of a flute or of an organ pipe." He occupied himself incessantly with chemical experiments, making many important discoveries, finding time, however, to do some occasional preaching before a Sandemanian congregation of which he was a member. He was a tireless writer as well as experimenter, and gave a vast number of articles of speculations, and the results of his investigations, to current scientific literature. In one year alone, he had no less than ten papers in the *Quarterly Journal;* and despite his other duties, he had always one paper, and often more, in progress at the same time.

It was in 1831 that he commenced the course of study and experiment which led to his discoveries in electricity, and which have conferred on him the greater portion of the popular fame which he enjoys. He brought the mixed theories of various of his predecessors as to magneto-electricity, into comprehensive form, and is believed to be the founder of the science as it exists to-day. He made many important investigations into the laws of electro-chemical decomposition; he developed a theory of inductive electricity; examined the magnetic relations of light; gave much study to the magnetic condition of gases; he made some examinations and study of submarine telegraphy. He gave nearly a quarter of a century to electrical researches. "The record of this work which he has left in his

manuscripts and re-published in his three volumes of *Electrical Researches*, will ever remain as his noblest monument; full of genius in the conception; full of finished and most accurate work in the execution; in quantity so vast that it seems impossible that one man could have done so much. Lastly, the circumstances under which the work was done were those of penury. During a great part of these twenty-six years the Royal Institution was kept alive by the lectures which Faraday gave for it. He had no grant from the royal society, and throughout almost the whole of this time the fixed income which the institution could afford to give him was one hundred pounds sterling a year, to which the Fullerian professorship added one hundred pounds more." *

It will be remembered as one of the facts connected with his career that, some years since, at the time the phenomena of spiritualism were exciting some attention, Faraday was induced to examine the "manifestations" known as "table-tipping." He did give the matter considerable attention; and after numerous experiments he reported that he found nothing supernatural in the movements of the table, and that the movements were made by those who had their hands on the table, through the means of unconscious muscular pressure.

In his old age, he was given a home at Hampton Court by the queen. Hampton Court is an aristocratic poor-house; once a famous palace, it is now a species of pauper-house to which are consigned the widows of deserving officers, and others who have given so much time to the state, and occasionally to science, that they have not had the time to accumulate any provision for their old age.

As to the influence which the development of electricity has had on civilization, it is needless to say a

* Dr. Bence Jones' *Biography of Faraday*.

force of the stone hatchet, and the weighty arguments of the club. Out of these savage conflicts grew not only the personal rights of property, but the rights of the family, the community, and the commonwealth. It was only the prick of the lance-head of flint that would convince many an ancient savage that the skin which his neighbor had won in the chase, was not his if he wished it; and the same of all the other rights that are vested in the individual and in the nation.

There is no record, however ancient, or rather document the most ancient, which fails to mention the existence of iron. The Vulcan of the Greeks, the Tubal Cain of the Hebrews, refer to an era in which iron was known; but back of these—if one may find chronological differences in the fabulous ages—in the dim past of the Egyptian dynasties, there seems reason to conclude that iron was known many thousands of years before the Christian era. It is also known that among the earlier peoples, iron was regarded as infinitely more valuable than gold; the latter was valuable only as an ornament; the former was the material which formed the swords, and which gave to its owner a supremacy over his less fortunate foe.

A few hundred years before our era, the existence of iron and its uses become substantially historical. Diodorus speaks of the great veneration in which it was held among the Egyptians; Herodotus shows how great was the value accorded to it in the mention of an iron saucer, which was deemed a present worthy to be given a king. Iron relics have been found at Nineveh, at Memphis, and in the pyramid of Gizeh. Among the remnants of the Chaldeans have been found ornaments in iron; writers living cotemporaneously with the beginning of the Christian era speak of very extensive mines of iron which were about exhausted from long working. Layard

discovered at Nimrud great quantities of spear and arrow-heads, pieces of armor, daggers, picks, saws with handles at each end, and other things which were wrought from iron. Were it not that iron so readily rusts, and thus becomes obliterated, there would be remnants of iron found among still earlier ruins of the ancient peoples. In the ruins of Nineveh there were found a wheel of copper with an axle of iron, some picks and chains, all in iron. At the time of the conquest of Gaul by Julius Cæsar, he found admirably made weapons of war, and ornaments made from iron. Steel was very early discovered by the ancients; not the steel of to-day, but the hardening of iron by plunging it into water.

The most remarkable remnant of early work in iron is the famous wrought-iron pillar of Delhi, which is supposed to have been erected in about the year 319 A. D. It is nearly forty-eight feet in height, is sixteen and one-half inches in diameter at the bottom, and twelve inches at the top. It weighs about seventeen tons. In a temple in India are iron beams of great magnitude, one of which is over twenty-six feet in length.

Of course, nothing is known of the processes which were in use among the ancients for the reduction of iron ore, save as we find them among the savage races still in existence, and who, not having been brought into contact with civilization, manufacture it presumably as have other peoples in their primitive conditions. Everywhere among the modern savages, save perhaps those in America, there is to be found some simple processes for the manufacture of iron. Livingstone found iron-working among all the African tribes which he visited; each had his furnace for smelting, its coal charcoal-pits, its forges; they constructed excellent hatchets, lance-heads, arrow-heads, bracelets, and other articles. Some of the

bellows which were used were very curious and ingenious in their construction. In the case of one village there was a double-acting bellows that would reflect credit on a much higher class of people. Each bellows was like a drum, the top of which, in place of being fast, was loose, so as to admit its being raised and lowered, as if for instance, it were of some very flexible skin. In the centre of this loose top was fixed a stick; at the bottom of the drum was a pipe which led to the fire. As the

PISTON BELLOWS USED BY SAVAGES OF AFRICA.

stick was raised and lowered by the natives, the air was drawn in the body of the drum and driven through the pipe against the fire; there was another drum, precisely like the first, which was operated by the other hand of the native, the handle of one being raised to admit the air as the other handle descended and forced the air against the flame; in this way a continuous blast was kept in operation. A stone near by furnished the anvil;

one native did the blowing, and second took the heated iron and hammered it on the stone-anvil to the required shape.

In India, there is in use the same kind of bellows, except there is a spring beneath the flexible part which forces it upwards. In working it, a man stands with a foot on each bellows and throws his weight on one, and then on the other, the spring forcing the top up as he shifts the weight from it to the other.

Among many of the savage races, the furnaces are made of clay, and the result is a very excellent article of iron; in other instances, equally good results are obtained by stacks which are dug in the hill-sides. In the charging of these primitive furnaces, the ore and charcoal are placed in alternately. In this way the natives, after a fire lasting from twelve to forty hours, get a mass of malleable iron which weighs from a few pounds up to one or two hundred. By repeated hammering, the cinder in the mass is expelled.

When Europe became familiar with the processes for the reduction of iron is not known. Perhaps as in the cases of the eastern nations, it was practiced in Europe from the earliest periods. The Romans, in their visit to Britain, found on their route a familiarity with iron and its working, but not, so far as is known, among the Britons. It was introduced by the Romans, for there are found abundant remnants of early workings. It is said that the form of furnace used in these very early days is yet in use in many parts of England. Also a furnace called the Catalan can be traced back to the beginning of this era; a furnace which is still in use in many parts of the world, including the United States. However, the earliest date at which reliable history takes hold of the reduction of iron in Europe, is from the fourteenth to the fifteenth century. Probably

iron metallurgy took its rise in Western Europe, towards the end of the fifteenth century. Of course, it had existed before this, but in no shape which resembles a permanent industry, In fact, it was not till the sixteenth century that the reduction of iron ore became an industry of great value; it even may be said that it did not develop its real value until the introduction of steam.

The introduction of the iron manufacture in England had the effect to menace the annihilation of the forests, which was met by laws limiting the amount to be cut for charcoal. It was not till the first part of the seventeenth century that a substitute for wood was found in mineral coal, when the process was patented by Dudley. He operated very successfully for a few years, and then died and took his secret with him into the grave. It was not till near the middle of the eighteenth century that Abram Darby invented the process of iron manufacture by the use of coal, in which he reduced the coal to coke before using it in the furnace. From that period, the manufacture of this metal has had no interruption. Steam came, and by its aid, the processes were vastly accelerated.

It may be said that the Dudley above referred to had the usual fate of inventors of those days. He was not the real inventor of smelting with coal; but it came into his possession on account of the inability of others to use it with success. He was the originator of it to the extent that he was the first who was able to use coal in smelting iron. The moment he made the process a successful one, he became an object of suspicion and dislike to others who were engaged in smelting by the old methods, and who happened to be in the possession of plenty of wood. They had a substantial monopoly of the business, and, of course, did not welcome opposition.

The result was that they incited the charcoal-burners to destroy the works of Dudley, which they proceeded to do on the ground that his process was one which would take the bread out of their mouths.

Something of the same sort has been heard before!

The first iron works in this country were established in 1819, near Jamestown, Va., but, some three years later, the works and working-men were annihilated by the Indians. The next effort was at Lynn, Mass., in 1648; at which works, in 1652, were coined the silver, "pine-tree," shillings, sixpences and threepences, which are so much in demand by the coin-collectors.

There was a very rapid improvement in the construction of smelting-furnaces after the handling of iron ore had become firmly established in Europe. The very earliest furnaces known, even those yet in use among the savage tribes of Africa, combine all the essentials of a blast-furnace; that is, a furnace in which there is an artificial aid given to the natural draught. Illustrations have been given of some of the primitive machines in use for producing the draft; but these were superseded by improved bellows, worked at first by water, and later by steam. At the outset, the cold blast was used the same as that in use among the native metallurgists; with the improvement in the dimensions of the furnace, the hot-blast was introduced—by whom does not appear, with certainty, although some authorities credit its invention to a Scotchman, named Neilson, who was a resident of Glasgow. Under this original invention, the air was heated previous to being driven into the furnace. The value of the invention, apart from its effect on the process of smelting, was that it permitted the use of hard coal for smelting purposes; its effect on the iron is not considered as beneficial, for the reason that, when a superior kind of iron is wanted it is smelted in a

cold-blast furnace. In some instances, the fuel which heats the blast consists mainly of the gases which escape from the furnace; the temperature attained by the hot-blast is sometimes from one thousand to fifteen hundred degrees. As a matter of economy in smelting, the hot-blast is invaluable; it adds about one-third to the value of the blast. It is estimated that for every ton of material in the furnace, there must be blown in three tons of air, whose effect, if cold, must be to greatly retard the smelting of the ore. There are many patents covering various forms of hot-blast furnaces: but they are substantially the same as to the end sought, which is to secure the greatest economy in the processes of heating the blast to the required temperature.

The introduction of the hot-blast, was not, as a matter of course, the only improvement over the ancient forms of furnaces. One of the first changes was to enlarge them from their primitive size. Now there are some furnaces which are over one hundred feet in height, and whose average "make" is more than five hundred tons per week. The process of smelting is familiar to almost every one in this country; but it may be briefly summarized as follows: The furnace is first charged with fuel, and as this burns down, alternate layers of fuel and mixed ore and limestone or other flux, according to the nature of the ore being smelted, are added. In a description of smelting, there occurs the following statement of the employé who had charge of the work:

"You must know that there are about one hundred and forty tons of material in the furnace, in the proportion of sixty to seventy tons of ore, sixty tons of coal, and fifteen to twenty tons of limestone, fed into the furnace at the opening above. The furnace is forty feet square at the bottom, and forty feet high, with a hollow space, or 'flask' in the centre, lined with fire-brick, and

about fourteen feet in diameter. The material dumped into the furnace becomes melted, and the iron, being the heaviest, sinks to the bottom, while the flux, like oil upon water, floats on the surface, and having an affinity for the dross of the coal and the iron, it grasps and holds it separately from the metal, until it is drawn off in what is called 'slag.' This is done once every hour. The gases evolved pass out at the chimney. The trouble is, the iron also has an affinity for the dross, and does, and will, retain some of it, notwithstanding all we can do.

"The floor of the building is a fine sand, divided into two parts by a track, on either side of which gutters, or runners, are formed, leading from the mouth of the furnace. At equal distances are eight branch gutters, or sows, as they are technically called, which conduct the molten ore to feed the pigs in the bed. All these are nicely formed by each set of hands after the previous cast has been cooled and removed.

"You see there are twenty-six pigs in a bed, and four pigs in a sow; that is, they break the sow into four pieces, each the size of a pig. There are sixteen beds, and consequently there are four hundred and eighty pigs, or about eleven tons in each cast. At each of the branch gutters or sows, a man is stationed with a spade, with which he prevents the metal flowing into his bed until the bed below him is filled, when he suddenly transplaces it, and, cutting off the flow downwards, turns it into his own bed. The next man does the same in succession, and when all the beds on one side of the track are filled, the flow is turned in the same manner into the other runner, and the process is repeated until all are filled, when the opening in the flask is closed by clay prepared for that purpose. New supplies of coal, ore, and limestone are dumped in above,

and the operation of smelting goes on for the next twelve hours. The pig iron is used either for casting, or for conversion into wrought iron by puddling, etc." *

When the iron is thus run off from the furnace, it is known as pig iron, and also is in that condition which characterizes it as cast iron. It is then sent direct to the foundry, to be cast into needed forms, or it has to undergo another process which converts it into wrought, or malleable iron; or into some of the various forms of steel.

In 1831, an American named Howells patented a process for the making of malleable iron direct from the furnace. It is described as combining within itself the advantage of a "close furnace and an open fire. In the upper part or close portion, being all that above the hearth, with anthracite coal, excited by a proper blast, a degree of heat is generated much greater than can possibly be obtained in the ordinary fire with charcoal; while the lower portion, opening into the hearth and permitting the free action of the blast upon the burthen, performs all the offices of the open or forge fire. The ore, descending to the regions of the tuyeres, becomes perfectly fused, and, passing below the influence of the blast, a part is driven out at the open front. The burthen in the furnace being temporarily supported by bars, the masses are gathered into a *loup*, which is removed by tongs and taken to the forge-hammer."

The processes in use for converting the pig, or cast iron into malleable iron, are several in number.

Steel seems to be almost as ancient as iron. When and by whom invented is not known, but it was in use some centuries before the beginning of this era, as is proved by the existence of the famous Damascene

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* J. R. Chapin.

sword-blades, which were of slips of iron and steel welded together. The mention in the Bible of steel is frequent, as it is among the ancient writers; but it is not known by what process it was produced. In modern days, the manufacture of steel is one of the most important industries, and the kinds produced are numerous, and varying as to quality. What is known as natural steel is, in some instances, produced from the ore by the use of a weak blast, which is directed in a horizontal line above the metal. The metal is not disturbed by stirring, and is kept covered by slag, and is thus retained until it is judged to be sufficiently refined. Cement, or blister steel, is another well-known product, which is obtained by piling bars of wrought iron, and layers of charcoal in a brick oven, which does not admit any air. The whole is then subjected to a high heat till such a time as it is supposed the iron has absorbed a sufficient amount of the carbon. Cast steel dates back to 1740, and is the invention of an Englishman, Benjamin Huntsman. His process was to place fragments of blister steel in a crucible of fine clay, cover them with broken green glass, and after having properly covered the crucible, and then placed the crucible in a furnace till the contents were melted, when they were drawn off in an iron mold. This is substantially the same process yet in operation for the production of steel used in producing many forms of tools. Huntsman is another example of a man who has produced great results without having the benefits of wealth and education. He was a German by birth; was of humble parentage, with no educational advantages, and a clock-maker by profession.

Perhaps the most noted steel is that known as the Bessemer, named after its inventor, Henry Bessemer, an English engineer, who was born in Herefordshire in 1813. He devoted himself to the improvement of machinery

for the manufacture of steel. His success was so great, that upon the production of what is known as Bessemer steel, it acquired a wide popularity, whose value is shown in the fact that his annual income from it was over five hundred thousand dollars; that is, the income from the royalty on his invention. For many years he held the field, and justly so, for the reason that his process was a substantial improvement; being, as was said by a high authority, the only one of one hundred and twenty-seven patents issued in England for improvements in steel which "had brought about any striking change in the mode of producing steel, or which had been attended with any real or practical commercial result." This was the decision of the jury at the World's Exposition, in 1862, in London. In 1867, at the Paris General Exposition, there was an assertion by the jury that he was not the first to attempt the "conversion of carburetted iron into steel, although he was the first to propose a practicable process for accomplishing so desirable an object."

It should be said that he did not attain an immediate success. His first patent was taken out in 1855; another was taken out the next year, after which, so many difficulties beset the progress of his improvement that he practically abandoned it. Aided by a suggestion from Robert Mushet, he overcame one of the practical difficulties of the process by the addition to the metal to be converted of spiegelsisen, and thenceforward his patent was a success. But the public had lost confidence in him, owing to his frequent failures, and refused to have dealings with him. Thereupon he started a small establishment of his own, near Sheffield, in which he demonstrated the value of his improvement, and it at once became a grand success. This was in 1859; in less than ten years his "converter" was adopted all over the

world. The main principle of his process is the blowing of a blast of air or steam through molten pig iron until the desired decarburization is produced. There are many processes of making steel which are akin to those in use in the Bessemer works. Krupp's steel is widely known. It is made of the best ore, which, after being melted, undergoes puddling, and then is melted in crucibles. The manufacture of steel by Krupp has amounted to as much as two hundred million pounds per annum.

In addition to the various steels mentioned, there are innumerable others, such as chromium, Tungsten, Damascus, Wootz, Baron, titanium, and thus on *ad libitum.*

In this country the Bessemer and the Martin processes are most in use. The latter is a French method, which has been less than ten years in use, and is quite as popular as the Bessemer process both as to cost and intrinsic quality.

The production of pig iron in the United States is something over three million tons per annum; from two to three hundred thousand tons of steel, and some two million tons of other articles. This is about one-half the product of England, about the same as the united product of France, Prussia, and Sweden. There is no reason to doubt that the time is not very remote when the total product of this country will exceed that of all these countries.

One of the most common machines connected with the working of iron into the various forms required is the rolling-mill. Next to the blast-furnace, the rolling-mills occupy the most prominent place. Before the invention of the rolling process, hammering was resorted to for the shaping of iron; and as may readily be imagined, the labor was not only an arduous one, but one which was capable of covering but comparatively little

ground. The first rolls in use were plain, that is, there were two rollers placed face to face, with unbroken surfaces through which the metal was passed, by which it must have increased in width as it diminished in thickness. The invention of the modern roll, which has its surfaces cut into grooves, and which is one of the very greatest improvements in the process of so shaping iron, is due to Henry Cort, of England, who patented the rolling process as a substitute for hammering, in 1783. The next year he patented the puddling process.

Cort was born in Lancaster, in 1740, and died in 1800. He began life, after reaching manhood, as an iron merchant, and later erected iron works, and then entered on a costly course of experiment with a view to improving the processes of rolling and puddling iron. It is estimated that he expended over one hundred thousand dollars in these efforts. In 1783 he was granted a patent for "machinery, furnace, and apparatus for preparing, welding, and working various sorts of iron;" and the next year, he was given another patent "for shingling, welding, and manufacturing iron and steel into bars, plates, and rods of purer quality and larger quantity than heretofore, by the more effectual means of fire and machinery." During all this labor he encountered the most persistent opposition from the iron-workers of Great Britain, who feared probably that his improvements would render theirs useless, or would at least create an opposition which might be ruinous.

For a time, after the granting of his patents, Cort flourished. He secured through an influential partner whom he had given an interest in his business, considerable contracts from the government; but his partner died suddenly, and Cort was involved in heavy lawsuits on account of the debts which had been contracted by the deceased. His works were broken up, mainly by the

government, the principal creditor of the partner. He was reduced to the necessity of taking service under others, and thus passed the remainder of his life. He effected a revolution in the iron trade by his inventions; and died poor among those whom he had made wealthy by his ingenuity. The only recognition he ever received for his great services was a pension of two hundred pounds granted him by the government when he was fifty-four years of age, and six years before his death. He is known as the "Father of the British iron trade."

Cort's invention cut grooves into the surfaces of the rollers; and this is substantially that which is in use at the present time. The grooves decrease gradually in size; and through these the metal is passed until it becomes of the required shape and dimensions. By the rolling-mill processes, iron is shaped for innumerable uses, as in the various forms of rails for railway tracks, and other articles; for building purposes in all the forms known in building iron; and by this rolling-machine we get sheet-iron in all its varieties, boiler-plate, the armor for ships, and hundreds of other things too numerous to particularize. Most delicate as well as irresistible are these machines; they furnish the armor of a ship three feet—if necessary—in thickness; and when a piece of tin, on which is spread a delicate lace fabric, is passed through the rollers, the finest mesh of the lace is imprinted perfectly on the metal.

The rolling of armor-plates for ships of war is about the heaviest work which is done by these mills. The following description by an anonymous writer will afford a lively and striking picture of how the labor is accomplished; the purpose being to secure a plate twenty feet in length, four feet in width, and fifteen inches in thickness.

"The plate, when laid in the furnace, rests on little

stacks of fire-bricks, so that the flame and heat play equally around it, till all is glowing white, and the successive layers have settled down into one dense mass. At a signal from the furnace-man, the bands of workmen, to the number of about sixty, arranged themselves on each side of the furnace, as near to it as they could bear the heat. Then the doors were opened to their fullest, and in the midst of the great light lay a mass even whiter than the rest. To this some half a dozen men drew near. They were all attired in steel leggings, aprons of steel, and a thin curtain of steel wire-work dropping over their faces like a large, long visor. All the rest of their bodies was muffled in a thick, wet sacking. Thus protected they managed, with the aid of a gigantic pair of forceps slung from a crane above, to work, as it were, amid the flames for a few seconds, and to nip the huge plate with the forceps. The signal was then given, and the whole mass of iron, fizzing, sparkling, and shooting out jets of lambent flame, was by the main force of chains attached to the steam rollers, drawn forth from the furnace on to a long, wrought-iron car. The heat and light which it then diffused were almost unbearable in any part of the huge mill, but the men seemed to vie with each other to approach and detach the colossal pincers which had drawn the iron forth. More than a dozen attempts were made on this occasion before this was effected, and more than a dozen of the best and the most skillful workmen were driven back one after another by the tremendous heat and glare. At last all was made clear. The forceps, then red-hot from their grip of the plate, were drawn away, the chains cleared from the rollers, and with a great hurrah, the other workmen seized the chains attached to the iron truck, and drew it to the incline by main force, where it was left by its own weight to run into the jaws

of the rolling-mill. It was then *sauve qui peut* among the workmen, who rushed for shelter in all directions as the mass was nipped between the rollers, and wound rapidly in amid quick reports like those of dull musketry, as the melted iron was squeezed by the tremendous pressure of the mass, and flew out in jets of liquid fire on all sides. The turning of the rollers crushes the plate through to the other side, where it rests for a minute on a wrought-iron truck similar to that on which it was brought to the furnace. The action of the rollers is then reversed after they have been, by the action of screw levers, brought closer together by about an inch. These again nip the plate, and drag it back in an opposite direction, and again and again does the mass go forward and backward, each time passing a smaller space between the rollers, till the whole of the huge thickness is reduced to a compact mass fifteen inches thick, in less than a quarter of an hour. During every stage of the process, quantities of fine sand are thrown on the plate, and this literally takes fire as it touches the flaming surface, and covers it as it melts with a coat of silica, or with a glaze like that of earthen-ware. After every discharge of sand, and these go on almost incessantly, buckets of water are thrown on the plate, and explode in clouds of scalding steam; and when these are partly dissipated, men rush forward and with wet besoms, with handles twenty feet long, sweep off whatever little scraps of oxidation may have taken place. Thus, every time the plate passes through the mill the sand is scattered, the water thrown, and the surface swept; and at every roll the chief roller of the establishment runs forward, and under the shelter of wet cloths, measures with a gauge its thickness from end to end. The required dimensions were obtained by less than a quarter of an hour's rolling, and a plate fifteen inches thick, the

product of the labor of nearly two hundred men, and of the consumption of nearly two hundred and fifty tons of coal, was shot out by the rolling-mills and left to cool. When this had been effected, two large rollers of iron, each weighing fifteen tons, were placed upon it by the cranes, and moved slowly backward and forward; and eventually, as the plate cooled, were left on its ends to keep the whole perfectly level. Nothing further now remained in order to complete it as the finest specimen of armor-plate manufacture ever attempted, but to plane off its rough ends and edges. The flat surface on either side, which formed what is called the skin of the plate, are never interfered with, for the action of the steel rollers leaves them literally almost as smooth as plate-glass."

This plate was rolled at Sheffield, England, in 1862.

CHAPTER XXX.

THE AGE OF IRON.—CONCLUDED.

SOME of the most astonishing results connected with the development of iron are to be found in shipbuilding. It was not till about 1830 that iron vessels began to take the place of wood, the first to suggest the change being John Laird, of Birkenhead, England. He built some cargo-lighters; but the credit of constructing sea-going vessels is due to Sir William Fairbairn, the eminent English engineer, who was born in Kelso, in 1789, and died in Manchester in 1874. He was of humble parentage, and learned engineering at a colliery. In time, he entered into business on his own account as a machinist, and while thus engaged he made several important inventions in various directions, such as simplifying the machinery for driving factories, improvements in steam-valves and double-flued boilers, and the invention of the riveting-machine. In 1831, he constructed the first iron vessel in England. From this time, the building of vessels of iron continued without interruption, and has grown to be one of the most important industries of modern days. It was from an investigation conducted by him, that wrought-iron girders were introduced into building operations. He also gave attention to the construction of tubular bridges of iron; and also devoted much time to lectures and

publications on various mechanical topics. He was made a baronet in 1869.

In many cases, ships are constructed in which iron is used to strengthen the frame, but in a very great number of cases the entire body is constructed of iron. Iron ships are lighter than those of the same tonnage built of wood, and are, therefore, proportionately more valuable for the carrying of freight. All of the great ocean steamers are now made of iron.

It was not until 1858 that a vessel was constructed of steel. The advantage of this class of material over iron can be readily seen; it is much stronger than iron, hence the same strength can be obtained with about one-half the weight. But it is in the construction of armored vessels, that the use of iron in ship-building has found its most extended and pronounced development. This use of iron, however, is no new thing. It is thought by many that the first use of iron for the defence of ships was during the late civil war; but this is far from being the case. It was the manner in which it was used, and not in the fact that it was used as armor which was original in the "Monitor," that checked the course of the "Merrimac."

The use of armor for the protection of ships, during battle, is as old almost as the employment of ships for warlike purposes. The triremes of the Romans had special defences; in the twelfth century, the Normans placed a belt of iron around their vessels just above the water line, that being the most vulnerable part of a ship subjected to the fire of artillery; and it is said that the Crusaders of the twelfth and thirteenth centuries protected their vessels in the same manner. Rawhide was employed in some cases as an armor; in 1535 a vessel was plated with lead, and very easily withstood the cannon of that period. The "Fulton II.," built by Robert

Fulton, in 1838, had a thin plating of iron. Gen. Paixhans, in 1834, recommended that the French vessels of war should be plated with iron, but the suggestion was not adopted. In 1835, John Podd Drake, an Englishman, proposed that the English navy be iron-clad; and in 1842, Robert L. Stevens, whose name has so often been mentioned in connection with steam-boats and other improvements, recommended to the United States government the advisability of building iron-clad steam-batteries for the defence of our ports. After finding by experiment that four and a half inches of iron was proof against any artillery known, the battery was commenced in 1854. It was not finished in 1874; its present condition is still that of progress. At the present time the heaviest armor-plates in use are some fifteen inches in thickness.

The first case in which iron-armor was used, was in the war between England and France, and Russia. The next notable case was when the "Merrimac" came into Hampton roads, and encountered Ericsson's "Monitor." Since that period, the navies of the world have been reconstructed; and now, like the knights of the feudal ages, they are clad in iron in every exposed part.

In its use, in this direction, iron may be said to be performing missionary labor. The strife between projectiles and defensive armor is about in equipoise; both have reached their extreme limit; and the result must be that offence and defence will come to a dead-lock. Drawn contests are of no value; and the consequence will be that there will be a tendency towards their decrease.

Iron, under its later developments, has rendered possible that which was before impossible. Especially is this the fact in building operations; that is to produce structures of the largest dimensions, which shall be light

in material, strong as a whole, fire-proof as to quality, and ornate in construction. Those who have seen the buildings in which the various world's expositions have been held, will agree in the conclusion that without the improved modern machinery, nothing approaching these fairy structures could have been erected. As a rule, they have been glass set in iron frames; they have been filled with light in every nook and aperture; they have been strong, light, fairy-like in their whole, and more like one of the structures which Aladdin conjured with his lamp, than any other class of modern construction.

There are many railway stations in the world that are notable monuments of what can be done with iron under modern treatment. A very marked instance of this can be found in the St. Pancras Station, of the Midland Railway, London. The building covers ten acres; the roof is six hundred and ninety feet in length, with a clear span of two hundred and forty, and its height at the ridge is one hundred and twenty-five feet above the level of the tracks. The Union Railway Station in New York, and others in various parts of this country, and in cities here and there in the old world, amply demonstrate the utility which iron possesses under the manipulation of modern genius and invention.

In many essential respects, by far the most marvellous results which are obtained from iron are in the operations of bridge building. Of these, the most wonderful are suspension bridges. These, although not of modern date as to the principle of suspension, are exclusively modern in the sole use of iron in their construction. The first of the kind was built in 1819, across the Tweed at Berwick, by Sir Samuel Brown. Its span was four hundred and forty-nine feet; the span of the bridge over the Menai, built by Telford, was five hundred and

eighty feet; that at Fribourg, built by Chaley, in 1831, is eight hundred and seventy feet, and the height above the river is one hundred and seventy-four feet. Roebling's celebrated suspension over Niagara river, is somewhat less than this, having a span of but eight hundred and twenty-one feet, although it excels the other vastly in its height above the water, being two hundred and forty-five feet above the torrent beneath. All these are excelled by the suspension bridge at Cincinnati, which is one hundred and three feet above low water and has a span of one thousand and fifty-seven feet; but even these extraordinary dimensions are excelled by the bridge which connects New York and Brooklyn, which is high enough to permit the masts of the largest sailing vessels to pass beneath it, and which has a clear span of one thousand five hundred and ninety-five feet, and a total length of three thousand four hundred and seventy-five feet.

There are still other bridges worthy of note. The railway bridge which crosses the St. Lawrence, at Montreal, is a tubular structure, which is over two miles in length, and cost some five million dollars. It is a substantial tube of wrought iron, carried on piers of masonry, and is constructed after the plan of the Britannia and the Conway, both designed by Stephenson. "The tubes which constitute the bridge, were constructed at a distance from their respective destinations, and afterwards floated to their places by pontoons, and raised by hydraulic presses, forming the most gigantic application ever made of these powerful machines."

A very remarkable bridge is that which crosses the Mississippi River at St. Louis, which was designed by Capt. James B. Eads, and which is very largely constructed of steel. There are four piers of limestone and granite, which were sunk to their places with immense

difficulty, in one case having to be carried down through sand for a distance of one hundred and twenty feet. The entire cost of this structure in connection with its approaches is something like ten million dollars.

The highest bridge in the world is in the Andes in Peru, and is for the use of the Lima and Oroya Railway. It crosses a mountain stream, at a point twelve thousand feet above the level of the sea. The Tay bridge, whose fall with a railway train laden with passengers, not one of whom escaped, is yet remembered with a shudder, was what is known as an iron truss-girder; was over ten thousand feet in length; it had three spans of sixty feet, then twenty-two of one hundred and twenty feet, then fourteen of two hundred, then sixteen of one hundred and twenty, followed by twenty of sixty-six feet, next one of one hundred and sixty, and the concluding six of twenty-seven feet each. There were in all eighty-nine spans, and the height above the stream, seventy-eight feet. One of the handsomest bridges in this country is the Girard Avenue Bridge, of Philadelphia. It is one hundred feet wide, and is entirely of iron.

Capt. James B. Eads, the builder of the St. Louis bridge, is yet a young man, but already a famous one. He was educated as an engineer, and has already executed some engineering works of which the St. Louis bridge may be considered one of the greatest, but the others are far from being of second-rate dimensions. Indeed, there are many who will not hesitate to assign him the very front rank among the engineers of the world should he succeed in his present undertaking, which is to so deepen the southwest pass at the mouth of the Mississippi river as to present through the bar at that point a navigable depth of water. His plan of deepening the mouth was finally adopted in face of the

THE ST. LOUIS BRIDGE.

opinion of some of the most experienced engineers in the United States; and if he shall succeed, it will be a disappointment to many eminent experts who have believed that his system is calculated to produce effects precisely opposite to those he is aiming to accomplish.

The theory of Captain Eads was that the narrowing of the channel of a river increases the rapidity of its flow, and proportionately increases the amount of sediment carried away. He thought that the "great mass of earthy matters discharged at the mouth of the river was not pushed or rolled along the bottom, as was generally supposed, but was brought there almost wholly in suspension; and that an intimate relation exists between the velocity of the current and the quantity of matter held in suspension; that the slightest retardation of the current, other conditions being unaltered, would permit the deposition of a portion of this burden, and that, conversely, the slightest acceleration of it would cause the water to take up from the unstable bed of the river an additional quantity." His opinions were fought by the United States engineers; his proposal to construct the works at his own expense, was rejected in the house; and it was only after a long and savagely-fought battle that the contract was given him with the understanding that his pay depended wholly on his success. The nerve of Eads may be inferred from his willingness to undertake a work costing millions, in the face of hostile opinions from eminent experts, and upon the condition that he was to receive nothing in case of a failure. He began the work in 1875, and has already, by the jetty system, succeeded in producing a depth of water which entitles him to a considerable portion of the amount appropriated for the improvement. The jetties constructed by him have not finally demonstrated a success which is without flaw, for this will be tested only by time; but even

what he has already done is sufficient to prove that he is a grand intellect; one who does not hesitate to meet odds however great, and to persist in efforts which would discourage a less daring spirit.

Capt. Eads has also devised, or invented a remedy for the jamming which has often been experienced in the revolving turrets of the monitor class of iron-clads. His invention is to allow the turrets to remain stationary, and revolve the guns.

John A. Roebling is another engineer who has taken high rank, more especially in the building of suspension bridges. He was born in Muehlhansen, Prussia, in 1806, and came to this country in 1831. He had been educated in the Polytechnic School of Berlin, and at once entered on the practice of his profession on his arrival in the United States. He introduced the manufacture of wire ropes, and their use in suspension bridges, his first structure being a suspended aqueduct, in Pennsylvania, in 1845. He soon after built some other aqueducts of the same kind, and also the suspension bridge across the Monongahela at Pittsburg. His first great work was the suspension bridge across Niagara river, which was completed about 1855; and in 1867, he completed the suspension bridge at Cincinnati. He appropriately finished his colossal works by furnishing the design for the great bridge connecting New York and Brooklyn. He died in the last named city, in July, 1869.

In the operations of forging iron, there was not much done in masses of large dimensions until the invention of the steam hammer. Prior to its invention, there were several hammers in use, which were driven by power of horses, water, and steam; and in all of which the machine hammer had a handle and a head, and was worked by machinery that raised it so as to imitate the motion of the human arm. The invention of the

steam-hammer did away with the handle, preserved only the head, and arranged so that the blow should be given by the force gathered by the hammer as it falls from a height. The principal involved in this case is substantially that of the pile-driver.

Several attempts were made to invent a steam-hammer, but none were successful until 1838, when the invention was made by a Scotchman named Nasmyth. There was a necessity for its invention, and it was this necessity which forced the effort. The steam-ship "Great Britain" was being built, when it was found that there was not a forge-hammer in Great Britain powerful enough to shape the paddle-shaft of the vessel. Nasmyth very soon produced a hammer which has substantially all the essentials of that in use at the present time. It was simply an upright cylinder, carrying a piston, which was extended down and ended in a heavy head of iron. When the piston was at the lower end of the cylinder, the steam was admitted beneath the piston, and raised it to the top; then the steam was allowed to escape, and the piston fell by its own weight to the bottom, the weight of iron at the end acting as the hammer. Some improvements were afterwards made, steam was admitted above the piston when it was raised to the upper end of the cylinder, and by its expansive force increased the fall of the hammer.

James Nasmyth was born in 1808, in Edinburgh, and graduated from the school of arts in that city. He established an extensive manufactory of machinery in 1834, and with which he was connected till 1856. He was the inventor, not only of the steam-hammer, but of the pile-driver, and in addition to these he constructed some cannon after a pattern of his own, and some powerful telescopes for lunar examination. He was also an author, an inventor by profession, and a very valuable

man to the present age of practical development. He had rather a singular experience with his invention of the steam-hammer. As said, he was asked to provide a hammer large enough to forge the paddle-shaft of the "Great Britain;" he furnished the plans, when just then the screw-propeller came into prominence, and no further attention was paid to his design. He thereupon abandoned the matter. Several years after he visited Creusat, France, and in passing through the iron-works, he noticed a steam-hammer driven on the plan which he had made. Enquiry developed the fact that, some years before, the superintendent of the works had seen the plans of Nasmyth, while on a visit to England, and had at once adopted them. He returned to England, and in 1842 obtained a patent for his invention.

Hammers driven by steam range from a weight of one hundred pounds up to one hundred tons. One of the last-named weight is in use in the Krupp works in Essen; the largest in the United States is said to be that in the Bessemer works at Harrisburg, and weighs thirty-five thousand pounds. Another very powerful forge-hammer is the one in use in the Woolwich Arsenal, in England. Its actual weight is forty tons; but its blow is greatly increased by the fact that it is accelerated by the admission of steam above the piston; the result being that the blow given is estimated to be the same as it would be were the hammer allowed to fall of its own weight a distance of eighty feet.

Some of these gigantic hammers cost a fortune to establish them. That of Krupp cost about a million dollars; the one at Woolwich about a quarter of this sum; and the one at the Bessemer Steel-Works, at Harrisburg, nearly one hundred thousand dollars. The force of the blow struck by the Woolwich hammer is estimated at eight hundred tons. The entire iron entering into the

construction of the Woolwich hammer is estimated to weigh some one thousand two hundred tons.

The invention of the steam-hammer has very largely extended the uses of iron; that is to say, it has enabled the forging of larger masses than under the processes formerly in use. It has made possible the enormous guns which have lately come into use; the eighty-one ton gun of Fraser; the one hundred ton gun of Armstrong, and the gigantic steel guns of Krupp. In the forging of the great shafts in use for the propellers, the steam-hammer is indispensable. The increased power of the rolling-mills is making possible larger work; in fact the tendency of the forging of iron is towards the colossal. On the other hand, there is an equal increase in the invention of machines for the construction of the little. At the time of Fairbairn, at the beginning of the century, all the work in the building of machinery was done by hand; now labor-saving machinery is the rule. The planing-machine is an invention which secures perfect results in the surface of iron; something which never was done to even approximate perfection by hand; and is a machine by whose aid, for the first time, a modern machine can be constructed to do exactly the work demanded of it.

The manufacture of wire is a case in which machinery occupies itself with the minute. Formerly, wire was cut out of sheets with infinite slowness, now it can be drawn at the rate of three to six feet a second. Without this machinery, the telegraph system would be an impossibility, or else would have been constructed at such a cost as to render impossible its popular employment. Tacks, whose utility is universal, and whose use is indispensable, are made by machinery at an incredible rate of speed. Knight says that "it is not an uncommon occurrence for an English tack-maker to forge one

thousand two hundred tacks, so small that they may be contained in the barrel of an ordinary goose quill." Once pins were made by cutting brass wire into the proper lengths; then the point of each was made on a grindstone; then a slender piece of wire was bent into a circle for a head, and was fastened on the body of the pin. It must have taken an expert workman not less than a minute to construct one of these useful articles; now the wire is drawn from a reel cut off the proper length, carried successively to a coarse and fine grind-stone, then to a place where it is heated and then is dropped into a receptacle, complete except as to polishing; and all this by machinery. After being polished they are stuck by machinery on paper. This improvement is owing to Wright's invention, which was given to the world in 1824.

As humble an article as is a pin, it is not without a history and an ancestry as old as the oldest. It is almost safe to assume that pins came into existence at the date at which woman made her appearance, or very soon after. Wherever ancient ruins have been overhauled, pins have been found among the remnants. It was introduced into England, as a manufacture, in the seventeenth century, and in this country in 1812. During all this period pins were constructed in the clumsy and laborious manner above narrated. In 1824, Lemuel W. Wright, of Massachusests, patented in England some machines for the making of solid-headed pins. There have been several improvements in this country patented since the time of Wright, but the most important was that of Samuel Slocum for putting the pins on paper. This patent, issued in 1840, was considerably improved by the genius of another American, Thaddeus Fowler, of Connecticut, whose machine is in principle the one now in use. Iron now enters very largely into the manufacture of pins.

As yet, machinery is employed but comparatively little in the manufacture of needles, for the reason probably that the ingenuity of the Yankee inventor has not been extensively turned in this direction. In the making of horse-nails, there are several processes of manufacture by machinery in the United States, which are American inventions, and which have grown into such popularity that they have very largely supplanted the making of this class of nails by hand. The manufactured nail is really better than the hand-made, for the reason that the process is so rapid that it gives a uniform result both as to the size of the nail, and the degree of softness. Horse-nail manufactories, furnished with machines made in this country, have lately been introduced into England, and have established themselves to an extent which guarantees a speedy, permanent success.

There is no limit to an attempt which should be made to particularize all the uses to which iron has entered in our later development. There is scarcely a department of industry in which it fails to have a conspicuous position. It is omnipresent. Its utility seems as expansive as the civilization with which it is connected. Its responses increase with our demand; and like the advancement of the human race, there seems to be no limit to its value.

It can be foreseen that, as wood grows scarcer in this country, iron will become more and more in demand for building purposes. Entire fronts of business structures are now composed of this accommodating metal; the time is not distant when all the façades, and much of the interior will be of iron. As a substance to be associated with wood it is not valuable as a building material, for the reason that, in case of a fire, the wood furnishes the heat, the house is the furnace, the in-rushing air the blast in which the iron writhes, is twisted, torn from its

places of confidence as a weight-bearer, and in thus losing its own integrity, brings down that which it is relied on to uphold and support. But possessed of autonomy, unentangled by alliances with inharmonic associates, it will form a most reliable building material within the reach of all. It will need a little different treatment on the part of the architect; it must be so handled that it will be less rigid, stern, and forbidding in its natural severity; it must be toned down to the air of gentleness characteristic of the home of the family; it must be somehow given something which will be in harmony with the laughter of children and the symphonies of domestic life, and then, as the material from which to rear the walls and gables of the home, it will be without a rival. How this alteration can be made, how that which has infinite rigidity can be made to have an appearance of flexibility; how that which is grim and unyielding can be made to have a seeming of gladness and softness, is something which must be evolved by the artistic genius of the architect.

There is no good reason why iron should not enter more largely into art than it does at present. There are a thousand directions in art in which it can be utilized; for the fencing of parks and private grounds, it can be made at once useful and artistic. In such cases, there is almost no limit to the ideas which it may be wrought to develop—to the expressions which it may present. Every iron railing may be made to do more than simply to act as a protection, whether on bridge, or public square, or roof of house. For towers of various sorts, there is no material more economical, durable, and plastic under the hands of the artist than iron.

Already, more particularly among the French, has the use of this metal been greatly utilized in artistic embellishment while serving a useful purpose. The iron

gateway at the entrance of the De l'Elysée palace has a magnificent effect; and the iron grille of the Palais de Justice, is an imposing creation. The D'Arcole bridge is of iron, and is full of beauty, with its rounded and graceful lines, the easy and yet strong contour of its arch, and its general suggestion of slenderness combined with an assurance of endurance and strength. Another very handsome bridge is that which crosses the Rhine at Kehl; it is not constructed solely with reference to the qualities necessary to answer the demands of travel; this has been amply cared for. The artist joined his efforts to those of the engineer, and has produced a structure which is imposing, majestic, and in every feature suggestive of beauty and indestructibility. At Grenelle, France, there is a tower nearly one hundred and forty feet in height, which is connected with the tubes of the artesian wells, which is built of iron, is light, airy, delicate, elegant: and, as a whole, a triumph of artistic architecture.

Grand as is the mission of iron at the present time, its entire utility will not be unfolded until it shall have taken its place in the department of art now occupied by stone and other metals. Its services thus far have been the ministering to the wants, the necessities, and the conveniences of mankind. In time it will occupy no small space in ministering to their tastes, and then it will have attained the position which it is entitled to hold.

CHAPTER XXXI.

PHOTOGRAPHY.

THE art of Photography, although born within the memory of men not yet old, is to-day one of the leading art industries of the world. The first photograph was taken in about 1839; at this date, less than half a century later, photography has extended all over civilization. Its benefits have already been incalculable as to their number and dimensions.

Back of the photography of to-day is the daguerreotype; and back of the latter is a history that reaches into the last century. The photograph is, in the main, a chemical result; it was born of chemistry, and is one of the grandest of its many children. It is defined as the "art of producing the pictures of objects by the action of light on chemically-prepared paper, silver, glass, etc., or the art of receiving and fixing on such surfaces the images formed by the camera." It is based on the fact that certain substances, notably, chloride of silver, is blackened by exposure to the light.

The discovery of the influence of light cn certain substances was one of the first steps toward the photograph. This was first noticed in the middle ages by the alchemists; the Swedish chemist, Berzelius, in the first part of this century, published a list including a large number of bodies which were found to be subject to change through the effect of exposure to light. Before

the time of this celebrated chemist, as early as 1777, another chemist, Sheele, of Pommerania, had called attention to the action of the sunlight upon certain compounds of silver. It is generally agreed that Mr. Wedgewood, son of the originator of the celebrated ware of that name, Josiah Wedgewood, was the first who made an application of the principles of the chemical decomposition of light. This was in 1802. He placed a solution of the nitrate of silver on leather, and obtained copies of objects, but was unable to fasten them, although he spent a good deal of time in the effort, and was assisted in the attempt by Sir Humphry Davy. It may be observed that Wedgewood would not have added greatly to the reputation of his establishment if he should have succeeded in discovering photography. His pottery is on a level with that at Sevres, France, and is known all over civilization. His father, a poor man, was without education, learned the pottery trade with his brother, and in a few years rose to the head of the profession. He was first brought into prominent notice by the production of the "queen's ware," and later, by the development of many novel and beautiful designs in pottery, whereby, as one of his numerous biographers say, "he raised British pottery to a fine art."

In 1804, 1809, and in 1812, Dr. Thomas Young, Guy Lussac and Thenard, and Dr. Beard, respectively, made some chemical discoveries which brought the age some steps nearer the appearance of photography. In 1827, Joseph Nicéphore Niepce, of France, made some advances which induce many to ascribe to him the honor of being the inventor or discoverer of photography. He succeeded in producing some permanent pictures by a process which he termed heliography. He was born in 1765, in Chalon-sur-Sâone, and died in 1833. He was a

soldier for a year when he attained the proper age; but left the army on account of ill health, and in 1801, he commenced the study of mechanics and chemistry. In 1813, he commenced experiments with a view of discovering a method of fixing images on glass and metal, and with success, save that his process was so very slow that it was not of great practical value. The material which he employed to sensitize the surface on which the picture was to be taken, was bitumen, or asphaltum; but the object to be copied required several hours' exposure. In 1829, he entered into a partnership with Daguerre for the purpose of improving the discovery which he had made; but he died in 1833, six years before his process was brought to anything like a thoroughly practical result.

There are other aspirants to fame in connection with photography; but, as a matter of fact, the credit remains with Niepce and Daguerre. In the popular estimate, Daguerre is the one who is entitled to all the honors; but this is not in accord with the facts. What Daguerre did was to take the process discovered by Niepce, and bring it to a point where it became of practical value. That Niepce is entitled to a portion of the credit is shown by the action of the French Assembly, who, when the discovery of Daguerre was established, voted him a pension of six thousand francs, and one of four thousand francs to the son of the deceased partner.

William Henry Fox Talbot is credited in England with being the inventor of photography, although he did not bring his process before the public till 1840, the next year after the announcement of the discovery of Daguerre. It was not the same as that produced by the Frenchman; the latter produced his image on silver-plated copper; the Talbot process was one in which paper was sensitized by a salt of silver, and the image

developed by gallic acid. What he produced was what is termed negative, that is one in which the lights and shadow of the object are reversed in the picture. He received the medal of the Royal Society, and left his discovery open to the use of the public. Talbot's subsequent career had little reference to such investigations as are involved in the development of photography. He has published a considerable number of literary works, and has devoted much time to the deciphering of cuneiform inscriptions.

Despite the opposition of the Talbot process, Daguerre sprang at once into a world-wide notoriety. But this was mainly in the scientific world; the general popularity of the daguerreotype depended on its value as a portrait-taker, which could not be done by Daguerre. His process was used for taking anything rather than faces; it is due to an American that the daguerreotype attained its final popularity.

Louis Jacques Mandé Daguerre was born in 1789, at Cormeilles, France, and died at Petit-Brie-sur-Marne, in July, 1851. His first effort after he had reached manhood was scene-painting, which he is said to have excelled in, none of his Parisian rivals approaching him in the novelty, striking effects, and artistic fidelity of his designs. He obtained such excellent results that he was employed by an eminent artist to assist him in completing a panorama of Rome, and various other large cities; and during this labor he invented the diorama. He continued at this business until 1839, when he was induced by Niepce to enter into a partnership to improve the process which the latter had invented in the taking of pictures by solar light.

It is stated by Daguerre's biographer that the improvement made by him in the processes of Niepce were so great that the son of the latter consented that the

new discovery should go to the world under the sole name of Daguerre. The annuity which was paid him and Niepce by the government was the result of a contract by which the invention was to be made public, and the further agreement that any new discoveries which should be made by him should be given to the world. He was promoted in the legion of honor; and in addition to this, he became at once famous all over the world, a fame which he may continue to hold long after that of many other men shall have passed away.

Why should not Daguerre be famous? He gave the world something which found a lodgment in every household throughout the broad domain of civilization. He met a want that all possessed, but which few were able to gratify. Up to his day, men and women had depended on the paint and brush of the painter for such "counterfeit presentments" of themselves as they possessed; the cost was great even at the cheapest; the rich only could afford them; the great masses of the people were debarred from the enjoyment to be found in gazing at their own likenesses, or those of their friends.

Draper improved the invention of Daguerre, and in a moment the wall of expense which barred the poor from one of the chief enjoyments of the rich, fell to the ground. Everybody could have his or her image; friends and relatives, living thousands of miles apart, who had rarely or never seen each other's faces, were at once, as it were, brought face to face.

There is scarcely a family in the land which has not a collection, small or large, of daguerreotypes which were taken during the period which preceded the days of the modern photograph. Queer are these remnants of what is almost a bygone period! The gray-bearded man sees himself as he was when a callow youth, and wonders if it be possible that he was ever so fresh, so young, so

unripe. There is his wife as she was when they were married; how odd her dress, how queer her hair, how fantastic, and how long, oh, how long, it seems since he sat by her side for that picture! There is the wrinkled, benignant face, the kindly smile, the soft gray hair, the high back-comb, the stiff ringlets of the mother; the stern features, and yet the kindly eyes of the father. Here is cousin John, with his hair combed up on his head with an unmistakable starched-Sunday-clothes awkwardness in his position, as he sits bolt upright, his hands spread across his stomach, and so out of the focus they appear thrice the size of the average human hand; and here are Aunt Jane, and the minister, and his wife, and the college professor, and the baby that is dead, and so for dozens.

These old daguerreotypes are not kept on the tables of the salon; they are packed away in some old drawer, or trunk, and they are always coming up unexpectedly when one is not looking for them, and reminding one that there is a past when one was younger, and that gray hairs, thin and scattering, have taken the place of the thick, ebon locks which one sees in this shining old daguerreotype of ——— years ago.

There is a wonderful vitality in some of these daguerreotypes. Many of them are just as fresh, as clean-cut, as undimmed as they were when they were taken thirty years ago.

It is said that the first portrait ever taken from life by the new process was by Dr. John W. Draper, of New York, in 1839, to whom, as is said, is due the fact that the daguerreotype process was not limited to artificial views. Dr. Draper is one of the most noted men of this country; he was born in England, in 1811, but came to this country when twenty-two years of age. He has obtained a very high position as a chemist and physiologist, and

for many years has been at the head of the medical and chemical departments of the University of the city of New York. He has been a most voluminous writer, and has created a reputation which extends over both continents, his works being not only those relating to purely scientific subjects, but others, historical, political, and even religious; at least religious to a considerable extent, as is exemplified in his *Conflict between Religion and Science*.

The difference between the process of Daguerre and that of Talbot, may be defined; they came before the world at about the same time, and may, therefore, be confounded. In the Daguerre process, the plate on which the image was to be taken, was of copper, and silvered on one surface. It was first carefully cleaned so as to present a surface like a mirror. The plate, when thus cleaned, was exposed to the vapor of iodine, (who does not remember the blackish stains of iodine on the finger of the daguerreotypist?) when it passed through a variety of colors, until a full yellow, the color desired, was reached, and then was placed in the camera to be exposed to the light from the subject. After the proper exposure, it was taken into a dark room, and there exposed to the vapor of mercury. After this had brought out the image, the plate was dipped in hyposulphate of soda, which removed the yellow film produced by the vapor of iodine. It was next washed in pure water and dried, when the process was completed.

In the invention of the process of the Talbot, a sheet of paper was used instead of the copper plate. This paper was covered with a changeable salt of silver, and then exposed in the camera, after which the latent image was developed by the use of a solution of gallic acid. It could be multiplied a large number of times by a process of printing. The full process was as follows:

"Writing paper was coated with a solution of common salt, and after drying was brushed over with silver nitrate; by this means silver chloride was obtained, with a slight excess of the nitrate, in which condition it proved exceedingly sensitive to light. Various bodies, such as lace and ferns, were laid on this paper, and a reversed *fac-simile* of them in black and white was produced; and he fixed the impressions by solutions of bromides and chlorides. When such a reversed *fac-simile* was placed over similarly prepared paper, and the light allowed to act through it, the result was the formation of a *fac-simile*, only this time not reversed in shades." *

Talbot's invention was known as the calotype, or photogenetic drawing. What were the improvements which Dr. Draper introduced, by means of which portraiture became possible through Daguerre's invention, do not seem to be known; but whatever they were, they seem to have been valuable, for it is said that some daguerreotypes taken by him, at this early stage of the art, have never since been excelled.

There were some minor improvements made in the daguerreotype processes, but the next decided advance in photography was the discovery of collodion, in 1851. It is generally conceded that the discovery is due to Scott Archer. It is claimed by English authorities that Le Gary suggested collodion, but that Archer was the first to give it a practical value. The effect of the discovery was to almost at once revolutionize photography and drive the daguerreotype artist out of existence.

Collodion is a solution of gun-cotton in a mixture of alcohol and ether. When used in photography, it is poured on a clean glass plate, and in a few moments, the alcohol and ether have evaporated, leaving the collodion

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* W. de Wiveleslie Abney, F. R. S.

on the glass in the shape of a thin film. Next the plate is soaked in a bath of a solution of silver nitrate, and is then ready for exposure in the camera. The development is brought about by pouring on the plate some chemical preparation such as a solution of pyrogallic acid; and, after the image has been brought out, it remains to fix it. As in the case of the daguerreotype, this can be done by hyposulphite of soda, or a solution of cyanide of potassium. In the printing process, paper is prepared by sensitizing it, and is then laid beneath the negative, and exposed to the light of the sun. In this way a very large number of copies may be taken; and it is herein that the process has its greatest advantage over the daguerreotype, of which there must be a separate sitting for every portrait made. There is still another important advantage in the difference in weight of the results of the two processes; the daguerreotype is heavy, it requires an elaborate protection in the shape of an enclosing case; and thus is not easily sent by post. One daguerreotype takes up as much room in a collection as a dozen or more of the later production.

One visiting a strange country can now, with little trouble, bring back scores, or hundreds of views of notable objects, and portraits of distinguished people, while such a thing in the case of daguerreotypes would be impossible. There are a thousand reasons why the latter processes of photography should supersede its earlier ones.

Before the collodion process had reached a high state of development, the ambrotype was in considerable demand. It was a negative on glass, fixed, and taken away by the customer. The ferrotype, or "tintype" as it is popularly termed, is also a collodion process, and very popular on account of its cheapness, and the rapidity with which it can be taken. In order to avoid the

time and expense which would be involved in taking the ferrotype one at a time, the camera is provided with a large number of lenses, by which as many can be taken at once as there are lenses.

The number of processes which have grown from photography reach almost to the hundreds, the mention of which would occupy considerable space. A few of the more noted may be mentioned. It is true that the stereoscope is no part of a photographic process; but it is so intimately connected with the examination of photographic results that a brief notice of it may not be misplaced at this point. It is said that a stereoscope was invented by Prof. Elliott, of Edinburgh, some years before the appearance of the daguerreotype; that is, he conceived the plan of one, but did not construct it till 1839. About the same time, Sir Charles Wheatstone had produced a reflecting stereoscope, in which the observer looked into two small mirrors placed side by side, but separated by a partition which prevented each eye from seeing only its own mirror. These mirrors were inclined at an angle of about forty-five degrees, and thereby reflected into the eyes two pictures placed near the mirrors, and which thus seemed as one. Later, in 1849, Sir David Brewster invented a refracting stereoscope, which is the one which, in principle, is now in general use. The Brewster stereoscope is in so general use that it is not necessary to describe its construction. The effect of seeing the two pictures as one is to greatly strengthen them, giving them greater distinctness and bringing them more into relief.

An amusing anecdote is related of the first introduction of the stereoscope to some of the members of the French Academy of Sciences. "The Abbé Moigno took the instrument to Arago, and tried to interest him in it, but Arago had unluckily a defect of vision, which made

him see double, so that on looking into the stereoscope he saw only a medley of four pictures. The abbé then went to Savart, but he was quite incapable of appreciating the thing, for he had but one eye. Becquerel was next visited, but he was nearly blind, and consequently cared little for the new optical toy. The abbé, not discouraged, called next upon Puillet, of the Conservatoire des et Metiers. He was a good deal interested in the description of the apparatus, but unfortunately he squinted, and therefore could see nothing in it but a blurred mixture of images. Last Blot was tried, but Blot was an earnest advocate of the corpuscular theory of light, and until he could be assured that the new contrivance did not contradict that theory, he would not see anything in it. Under the circumstances, the wonder is that the stereoscope ever got fairly into France."*

There are stereoscopes constructed on a large scale in which, in some cases, are as many as several hundred pictures, and which by a simple piece of machinery, are brought consecutively into view.

Photo-lithography is a very important process, and which has been described in the article on engraving. In this connection it may be said that a large number of photographic processes have reference to producing negatives which may be used for various kinds of printing. Thus, there is the photo-gelatine processes and the autotype, by which a photographic image may be transferred to stone or metal from which impressions may be taken. Another process for the transferring of the image to a metal surface is known as photo-glyptic engraving; and still another of this class is the photo-galvanograph. Photo-intaglio engraving is a process by which lines are etched on a plate which is printed from on a copperplate press.

* *American Journal of Chemistry.*

In fine, photo-mechanical printing absorbs a large number of the processes of photography, which may be divided into those which are termed surface-printing, and others which are known as relief-printing. Among the former, as an example, is photo-lithography, and among the latter is photo-galvanography.

Photography has proved to be of great assistance in the study of the celestial bodies. This department is known as photo-heliography, and the first instrument was made by De la Rue, and has since been improved by Janssen and others. By means of the photo-heliograph the aspects of the moon have been very thoroughly pictured; the spots on the sun have been reproduced by the light furnished by the great luminary itself; and in eclipses of the sun, photography has been of the greatest service, not only to science, but to the popular demand for views of such occurrences. One of the missions of photography has been to assist in recording the transits of Venus, and in this labor the photo-heliograph has been the instrument relied on.

In astronomical observations, the ordinary camera is not used, but in place of it an ordinary astronomic telescope is converted into a photographic instrument. The first attempt to use photography for astronomical purposes was in 1851, by Berkowsky, of the Royal Observatory, whose result was a daguerreotype of an eclipse of the sun. De la Rue obtained, in 1860, some fine views of an eclipse by the collodion process; that which is now in use in photographic portraiture. The use of photography in connection with the stars was first begun in this country by Professor Bond, of Cambridge, Massachusetts; but its most industrious employer has been Lewis Rutherford, of New York, once the partner of Hamilton Fish, and who has given a large portion of his time to astronomical photography, concerning which

he has published numerous papers, which have given him a world-wide fame; and who has invented some very ingenious apparatus for the furthering of his favorite pursuit. He perfected the method of stellar photography in the construction of a photographic objective whose diameter is eleven inches, and whose focus is about thirteen feet. His telescope is moved by clock-work so as to follow the movement of the stars.

"The views of large stars taken with it, after a short exposure, all appear like small round points that can only be seen through a magnifying glass. In the case of a long exposure their size depends, fundamentally, on the more or less strong vibrations of the atmosphere, which occasion the flickering of the stars. Stars of the ninth magnitude can be photographed with an exposure of eight minutes; these stars are ten times weaker than the faintest that can be detected on a clear night by the naked eye, and their images are very small points. It would be difficult to distinguish these small points from dirt spots on the plate. To do this, Rutherford makes use of an ingenious process. He brings the telescope, after the first exposure of eight minutes, into a slightly different direction, and makes another exposure of eight minutes while the clock-work continues to operate, and moves the telescope correctly in this second direction. In this manner two images are obtained of every star on the plate, closely adjacent; the distance and the relative position being in all the same. These double views can easily be found on the plate and distinguished from spots. If the telescope stops, it is evident that the images of the stars make a movement on the plate, the bright stars describing a line. This line is of great importance to determine the direction from east to west on the plate. For faint stars which leave no line a third exposure is necessary to determine this direction; the

same thing takes place after the clock-work of the telescope has been stopped for some minutes.

"Rutherford has already taken numerous views of the stars, and they will serve as important means of comparison, after the lapse of centuries, in order to discover what change has taken place in the position of the fixed stars." *

Photographs are taken of the moon which shows its surface almost with the distinctness of a county map. Had astronomers been able to have taken these views a century ago, we should now be able to know definitely whether it be true that important changes are constantly occurring on that planet.

There are photographic apparatus for doing many other things than human portraiture, and recording the peculiarities of the heavens. These apparatus, and their uses, are almost innumerable. A very ingenious use of photography is for the registering the variation in a thermometer during periods when it cannot be observed. A strip of sensitized paper is made to revolve on a drum behind a thermometer, and is so arranged that light is admitted on it from just above the thermometer, while the column of mercury will not permit its passage. The result is that all above the mercury, on the sensitized paper, will be black, and the variation in the line of black will indicate the rise and fall of the mercury. The drum is arranged to revolve once in twenty-four hours; this is divided into twenty-four parts; and if the revolution be commenced say, at noon, the precise minute of the occurrence of a change will be shown. Photography is also of service, through certain machines, in showing the temperature of the ocean at great depths, and also the existence and direction of deep sea currents.

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* *Applications of Photography.* Vogel.

There are photographic instruments for photographing the drum of the ear, the interior of the throat, and for various purposes, chiefly in the interests of medicine.

One of the more curious, if not the most curious of the uses of photography is that which is applied to reducing the dimensions of objects, and known as microscopic photography. It has happened within a few years that the value of this process became very widely known, and proportionately appreciated. This was during the siege of Paris by the Prussians in 1870, when the city was cut off from the outside world by any of the usual channels. In this extremity, microscopic photography performed a most unwonted and useful part. Vast quantities of written and printed matter were reduced to microscopic dimensions by photography, and then sent out of the city by carrier pigeons, and by the balloon lines which ran with regular irregularity. The matter to be reduced was first set up in type, and printed on two pages side by side. A page of this matter, as large as that of the average newspaper, would be reduced by photography to a space of one and one-half inches. The surface on which the pages were photographed was simply a collodion film, having a scarcely appreciable thickness, so that as many as a dozen of them could be placed in the barrel of a quill. When the films reached their destination, they were unrolled, and "thrown up" by means of a magic lantern, when they were copied by writers, and forwarded to their proper destination.

Here the photograph succeeded in reducing almost to infinitesimal dimensions ordinary writing; it has equal power in the reverse direction. By the use of the micropantagraph, Mr. Peters of London, the inventor of the machine, succeeded in writing the Lord's Prayer

within the space of the one-three hundred and sixty-five thousandths of a square inch. If written in the same diminutive style, there could be twenty-two Bibles written within the space of one square inch. By the use of photography this class of writing can be developed.

Pyro-photography is a process by which glass and porcelain can be decorated in various colors, which process is thus described: "The collodion image—which as we have seen consists of minute parts of silver—is capable of manifold changes, and that, moreover, it is easily transferable, with its elastic collodion film, to other bodies. The film, with the picture, can be placed in different solutions, and then transferred to curved surfaces, etc. If the little collodion image is placed in a metal solution, a chemical change ensues. Assuming the metal solution to contain chloride of gold, then the chlorine passes over to the silver, of which the picture consists, chloride of silver is formed, and metallic gold is precipitated as a fine blue powder on the outline of the picture. Thus a gold picture is obtained. With certain precautions this can be transferred to and made encaustic on porcelain. By this means an unpolished image is obtained, which can be rendered brilliant by polishing. Gruene has employed this to produce gold ornaments on glass and porcelain. Drawings and patterns of different kinds are photographed; the image obtained is changed into one of gold, then burnt in, and thus the most beautiful and complicated decorations can be produced without the assistance of the porcelain painter. *

If the film be plunged into a solution of platinum, then a black image is produced on the porcelain or the glass; if a violet image is wanted, then the film is

* Vogel.

plunged in a mixed solution of gold and platinum; and in this way various tints and colors can be secured.

One of the problems which has most interested the photographer is one relating to the production of photographs in colors. There have been innumerable efforts in this direction; but there never has been anything which may be regarded as a successful solution. Of course, there is no end of photographs colored, but none in the natural colors, such as objects present when exposed under the camera.

The attempt to produce pictures in color was inaugurated before the discovery of photography, as far back as 1810, by Prof. Seeback, of Jena, who found that chloride of silver would develop the colors of the spectrum. Sir John Herschel, after the discovery of the daguerreotype, submitted a solar spectrum to a paper properly sensitized, and succeeded in getting a fair reproduction of the colors. Becquerel, whose name has before been mentioned, succeeded, by using only nitrate of silver, in getting better results than Herschel. After him there were other experiments by Niepce, Simpson, Poiteven, and one or two more, all of whom were enabled to produce an impression in colors, although none of them discovered any process by which the colors could be fastened. That is the condition in which photography is at the present time; no process has been found by which colors can be retained in the light. Almost everything is possible in science; it is most sincerely to be hoped that the result so long and ardently sought may be attained. Certainly photography needs not to be able to reproduce permanent colors in order to become perfect.

There might be an entire book devoted to photography, and yet the subject would be far from being exhausted. In this article, no more has been attempted

than to summarize a few of the salient points connected with its invention, growth and present condition. There are a dozen processes in the art which have not been even alluded to; of its advantage in the production of books, newspapers, and in a hundred other directions, there has not been an allusion. There has been no effort to reckon the extent of this industry, or its value in a moneyed sense, to the civilized world. All these details are of great interest; and he who wishes to master them will have to go through a thorough course of reading.

It may be said of the result of photography that it is an educator. By its use, there is within the reach of all the secrets in the products of art; the pictures of all the great masters may be seen in every print-shop, and in the album of every family. Through the same source, one who is not able to travel, can see without material expense, the faces of all the great men and women of the world; can examine the proportions of all the noted buildings in the old and new world; can familiarize one's self with the imposing machinery, cataracts, mountain-peaks, cities, churches, temples of Jerusalem, and of the Hindoos; the war-ships, the docks, wharves, the bridges; in fine, everything which is worth the trouble of a visit. In this way the exclusiveness of art, architecture, grand natural scenery, and aught else of the kind which is important, is being obliterated.

Justice, since the introduction of photography, has found it of very great assistance. This is especially so in the criminal departments. Everybody living in a city knows of the existence and character of the "Rogues' Gallery," in which are to be found the faces of well-known criminals. This measure, the photographing of criminals, is found to be of the greatest value as a means for the detection of crime. When a

man is suspected of a crime; that is, if he be a professional criminal, his photograph can be sent to other places, rendering his detection much more certain than under the old methods. Under the system now in use, the face of every professional criminal is to be found in the various police galleries, and thereby it is familiar to the police and the detectives. It is also of value in detecting men who have been guilty of a second offence. Their face once in the gallery of rogues, the fact is very easily established as to their being old offenders; and this is important, for, as is well known, the law makes a very broad distiction between a first offence, and second, and still other ones.

It would be a good thing if all papers which are liable to be lost should be copied by photography. In many cases, photography is invoked where forgery is suspected; but it is not used, as yet, to the extent which it might be with advantage. All unknown bodies should be photographed; the position of a murdered person and the surroundings would be of value in the efforts of justice to elucidate the crime, and to punish the guilty.

CHAPTER XXXII.

THE SEWING-MACHINE.

THE sewing-machine, as has been seen in the cases of many other improvements, is the invention of no one man. Like a vast number of machines, it was, in a manner, evolved. There is a long distance from the Marquis of Worcester to James Watt, the reputed inventor of the steam-engine, and yet, as a matter of fact, one of them is no more really entitled to the credit of having invented the steam-engine than the other. Watt improved it greatly, and for this is entitled to illimitable credit. Howe is credited by the majority of mankind as the inventor of the modern sewing-machine. It may have been a totally original idea with him, but nevertheless he was not the original inventor. A sewing-machine, probably not *the* sewing-machine, was known long before his machine was perfected.

The first patent granted for a sewing-machine was issued in 1755, to an inventor named Charles F. Weisenthal, in England. It can scarcely be called a sewing-machine save by courtesy; for it was simply a needle, pointed at both ends, with an eye in the middle, and was intended to be used by the hand and to be passed through the cloth without being turned around. This is the bit of protoplasm from which was evolved the modern sewing-machine.

In 1770, the bit of jelly had undergone some development, for at that period, Robert Alsop, in England, applied for and received a patent for a machine for using one shuttle or more in a loom for embroidery; thirty-four years later, 1804, there was also an English application for a patent by John Duncan, for the making of embroidery by a machine in which there were several needles. It is described as a machine in which "hooked needles were attached in a straight line to a horizontal bar, the forward motion of which carried all the hooked ends through the cloth, when, on being supplied with thread by a feeding needle, the reverse motion carried back loops which passed through and secured those of the previous stitch." * It is stated by the same authority that there "has lately been found in the archives of the English patent office a patent for a sewing-machine made by Thomas Saint, dated July 17, 1790, which has excited considerable surprise and interest in consequence of its possessing many of the elements of successful modern sewing-machines." According to the patent, it was intended "for quilting, stitching and making shoes and other articles by means of tools and other machines."

One of the names which have achieved fame by the connection of its owner with the invention of the sewing-machine is that of Thimonier, a Frenchman, who in 1830, patented a machine which went into use in the making of clothing for the army. A considerable number of them were made and put in use; but they met the not uncommon fate of exciting the prejudices of the mob, by whom they were set upon and destroyed. In 1846, he had other machines in operation which were an improvement over his first ones, but they were again

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* *Am. Cyclopædia.*

cared for by the mob; and this time, the inventor himself narrowly escaped with his life. This so wrought upon him that he gave up his efforts, and died in obscurity, and in great poverty. His machine has a clumsy appearance by the side of the light and elegant machines of the present day; but they were genuine sewing-machines, all the same, and were capable of doing very good work.

The Howe machine is dated 1846. Prior to his invention, there had been several others in addition to those which have been just mentioned. There was a machine patented by Lye, in this country, of which no record remains, as it was destroyed by the fire of 1836. In 1842, J. J. Greenough, of Washington, patented a machine which was designed mainly for the sewing of leather; and there are a half a dozen patents between 1840 and 1849, for machines for sewing together lengths of cloths previous to the bleaching and dyeing. The Corliss sewing-machine was patented in this country in 1843, and presented many of the features of the Greenough machine. The first machine to make the chain-stitch is that of Saint, already alluded to as being patented in 1790; the next is the Duncan; the next the Thimonier; then others by Garland, by Fisher and Gibbons, English patents, in 1844. There was one machine invented which was attached to a pair of shears, which made one stitch at each cut of the instrument.

There seems to be no doubt that a sewing-machine was invented, constructed, and put into use by Walter Hunt, of New York, in 1832–4, but who was so absorbed in other inventions that he did not give his machine the attention which it deserved. It was so much of a sewing-machine that when Howe's machine was brought out, he was sued for infringing Hunt's rights. Hunt thought so little of his machine that he did not apply

for a patent till 1854, and then he was refused one on the ground of abandonment. Had he attended to his invention at the time that he first made it, he would undoubtedly have had the princely remuneration which was gathered by Howe, Singer, and the other magnates of the sewing-machine. He is an illustration of the danger of having too many irons in the fire. He was a man of decided genius, every way the superior of Howe, and yet Howe obtained the millions which he could have put in his own coffers had he been as shrewd in business as he was capable of invention.

Elias Howe, who is known, in this country at least, as "the inventor of the sewing-machine," was born in 1819, at Spencer, Massachusetts. His father was a farmer and a miller, the latter including the running of several kinds of mills, such as a grist-mill, a saw-mill, and one for the manufacture of shingles. When a lad, he worked with his brothers and sisters in sticking wires into cards which were to be used for the carding of cotton; and when old enough, he assisted on the farm and attended the district school. When he was eleven years of age, he went to work for a neighboring farmer, but soon after left him, and went to Lowell for the purpose of learning the trade of the manufacture of cotton machinery; there was a financial crash, and the machine manufactory failed. Then Howe went to Harvard and entered a machine shop, where, at the same time, there was working his cousin, Nathaniel P. Banks, since a major-general in the United States Army, and speaker of the House of Representatives. Howe seems to have been of a migratory disposition, for after having worked a few months in this shop, he went to Cambridge, where he entered a shop for the manufacture and repair of nautical instruments.

It is here that he first conceived the idea of inventing

ELIAS HOWE, JR.

a sewing-machine. The time and origin of the conception are thus narrated:

"In the year 1839, two men in Boston—one a mechanic and the other a capitalist—were striving to produce a knitting-machine, which proved to be a task beyond their strength. When the inventor was at his wit's end, his capitalist brought the machine to the shop of Ari Davis, to see if that eccentric genius could suggest the solution of the difficulty and make the machine work. The shop resolving itself into a committee of the whole, gathered about the knitting-machine and its proprietor, and were listening to an explanation of its principle, when Davis, in his wild, extravagant way, broke in with these words:

"'What are you bothering yourselves with a knitting-machine for? Why dont you make a sewing-machine?'

"'I wish I could,' said the capitalist, 'but it can't be done.'

"'Oh, yes it can!' said Davis; 'I can make a sewing-machine myself.'

"'Well,' said the other, 'you do it Davis, and I'll insure you an independent fortune.'

"There the conversation dropped, and was never resumed. The boastful remark of the master of the shop was considered one of his sallies of affected extravagance, as it really was; and the response of the capitalist to it was uttered without a thought of producing an effect. Nor did it produce any effect upon the person to whom it was addressed. Davis never attempted to construct a sewing-machine.

"Among the workmen who stood by and listened to this conversation was a young man from the country, a new hand named Elias Howe, then twenty years old. The person whom we have named capitalist, a

well-dressed and fine-looking man, somewhat consequential in his manners, was an imposing figure in the eyes of this youth new to city ways; and he was much impressed with the emphatic assurance that a fortune was in store for the man who should invent a sewing-machine. He was the more struck with it, because he had already amused himself with inventing some slight improvements, and recently he had caught from Davis the habit of meditating new devices. The spirit of invention, as all mechanics know, is exceedingly contagious. One man in a shop who invents something that proves successful will give the mania to half his companions, and the very apprentices will be tinkering over a device after their day's work is done. . . . Before that day, the idea of sewing by the aid of a machine had never occurred to him." *

Before going into the details connected with the invention of Howe's sewing-machine—which was known as the "lock-stitch"—something may be said of another inventor who has obtained a celebrity wider perhaps than that of even Howe himself. In 1850, a man appeared in Boston with a carving-machine which he claimed as his own invention, and which he exposed for sale in a shop in which there happened to be some sewing-machines on exhibition. According to James Parton, who is a most enthusiastic advocate of any cause which he undertakes, this man with the carving-machine was "then a poor baffled adventurer. He had been an actor and a manager of a theatre, and had tried his hand at various enterprises, none of which had been very successful." And yet this "poor baffled adventurer," as he was then, not very long after took Paris and New York by storm with his lavish display of wealth; and who not long since

* *Atlantic Monthly*. May, 1867.

died the possessor of millions, and husband of more wives than he had millions—and the millions were many. This man, this "poor baffled adventurer," who was jack-of-all-trades and master of none, who was so soon to astonish the world with the splendor of his wealth, was Isaac M. Singer.

The proprietor of the shop in which Singer displayed his carving-machine was a man named Orson C. Phelps, and he, according to the testimony of Singer, showed him the sewing-machines on exhibition, and, in the course of the conversation, said to him that they were an excellent invention, but that they had some serious defects; and suggested to Singer that if he could make the desired improvement, he could make more money than he could by making carving-machines. According to the testimony of Singer, he was very much impressed with this statement, so much so, that during the night following he made a drawing which embodied three substantial improvements not contained in the machines on exhibition. The drawings were approved, and he thereupon found himself under the necessity of constructing a model. What follows is from the testimony of Singer in the suits which were begun against him for the infringements of Howe's patents. The purchaser of his carving-machine agreed to advance him fifty dollars, upon which he "flew at the work like a tiger."

"I worked," he says, "day and night, sleeping but three or four hours out of the twenty-four, and eating generally but once a day, as I knew I must get a machine made for forty dollars, or not get it at all. The machine was completed the night of the eleventh day from the day it was commenced. About nine o'clock that evening we got the parts of the machine together and commenced trying it. The first attempt to sew

was unsuccessful, and the workmen, who were tired out with almost unremitting work, left me one by one, intimating that it was a failure. I continued trying the machine, with Zieber, who furnished the forty dollars, to hold the lamp for me, but, in a nervous condition to which I had been reduced by incessant work and anxiety, was unsuccessful in getting the machine to sew tight stitches. About midnight I started with Zieber to the hotel where I boarded. Upon the way we sat down on a pile of boards, and Zieber asked me if I had not noticed that the loose loops of thread on the upper side of the cloth came from the needle? It then flashed upon me that I had forgotten to adjust the tension upon the needle thread. Zieber and I went back to the shop. I adjusted the tension, tried the machine, and sewed five stitches perfectly, when the thread broke. The perfection of those stitches satisfied me that the machine was a success, and I stopped work, went to the hotel and had a sound sleep. By three o'clock the next day I had the machine finished, and started with it to New York, where I employed Mr. Charles M. Keller to get out a patent for it."

There are many who doubt the statement thus furnished by Singer, and believe, or affect to believe, that his machine was a simple piracy. Be this as it may, it is certainly the fact that Singer was a man of ten thousand; whether or not he could invent a sewing-machine, he could at least sell one. He may not have been an inventor, but he was certainly a great business man. He opened a small shop for the sale of his machines in New York, first having by hard work scraped together enough money, with a partner, to commence the manufacture of his sewing-machine in a small way. "Great and manifold," says Parton, "were the difficulties which arose in his path, but one by one he overcame them all.

He advertised, he traveled, he sent out agents, he procured the insertion of articles in newspapers, he exhibited the machines at fairs in town and country. Several times he was on the point of failure, but in the nick of time something always happened to save him, and year after year he advanced towards an assured success. We well remember his early efforts, when he only had the back part of a small store in Broadway, and a little shop over a railroad depot; and we remember also the general incredulity with regard to the value of the machine with which his name was identified. Even after hearing him explain it at great length, we were very far from expecting to see him one day riding to the Central Park in a French *diligence*, drawn by five horses, paid for by the sewing-machine. Still less did we anticipate that, within twelve years, the Singer company would be selling a thousand sewing-machines a week, at a profit of a thousand dollars a day. He was the true pioneer of the mere business of selling machines, and made it easier for all his subsequent competitors." *

The Wheeler and Wilson machine has a history very like that of some others. In 1849, Allen C. Wilson, a cabinet-maker, in Pittsfield, Massachusetts, invented the machine which bears the name of his firm, without, as he asserts, and as asserted by his friends, ever having seen one, or known anything of the peculiarities of the Howe machine. He associated with him in the undertaking a young carriage-maker, named Nathaniel Wheeler, and together, after Wilson had completed his invention, they commenced together the manufacture of the machine which Wilson had succeeded in producing. At the present time, the house of Wheeler and Wilson is one of the most noted in the sewing-machine business.

* *Atlantic Monthly*. May, 1866.

Something of the same kind of independent invention is to be found in the rise of another sewing-machine, and with it of a house that has become famous. In 1854, a young Virginia farmer named James E. Gibbs, saw in a scientific paper a picture of a sewing-machine, but which exhibited only the upper portion, leaving concealed the means by which the stitch was formed underneath. He studied out a plan by which this could be effected, with the result that he devised an entirely new stitch developed by a revolving hook.

William O. Grover was a tailor in business in Boston, who invented what is known as the Grover and Baker stitch, and from thence arose the machine of that name, and the noted firm which manufactures the machine carrying the name of the firm. This was in 1849, after Howe had returned from Europe. All these firms had entered the field, and arrayed themselves as the antagonists of Howe, and prepared to dispute at any cost his claim as the inventor of the contrivance.

It is now time to return to the invention of Howe, and the details of its evolution. It is a history which has all the qualities of a first-class romance. In fact, few romances equal in interest the details of Howe's struggle and the splendor of his victory.

The following is Howe's history of his invention:

"I commenced the invention of my sewing-machine as early as 1841, when I was twenty-two years of age. Being then dependent on my daily labor for the support of myself and my family, I could not devote my attention to the subject during the working hours of the day, but I thought on it when I could day and night.

"It grew on, till in 1844 I felt impelled to yield my whole time to it. During this period I worked on my invention mentally as much as I could, having only the aid of needles, and such other small devices as I could

carry in my pockets, and use at irregular intervals of daily labor at my trade. I was poor, but, with promises of aid from a friend, I thereafter devoted myself exclusively to the construction and practical completion of my machine. I worked alone in an upper room in my

HOWE'S FIRST SEWING-MACHINE.

friend's house, and finished my first machine by the middle of May, 1845.

"This was a period of intense and persistent application of all the powers I possessed to the practical

embodiment of my mechanical ideas into a successful sewing-machine. I soon tested the practical success of my first machine by sewing with it all the principal seams in two suits of clothes, one for myself and one for my friend.

"Our clothes wore as well as any made by hand-sewing. I have my first machine still; and it will now sew as good a seam as any sewing-machine known to me. My first machine was described in the specification of my patent; and I then made a second machine to be deposited in the patent office as a model. I then conveyed one-half of my invention and patent to my friend for five hundred dollars; in fact, though a much larger sum (ten thousand dollars) was named in the deed, at his suggestion. My patent was issued on the 10th of September, 1846. I made a third machine, which I tried to get into use on terms satisfactory to myself and friend. For this purpose I endeavored to attract notice to it by working with it in tailors' shops, and exhibited it to all who desired to become acquainted with it.

"After my patent was obtained, my friend declined to aid me further. I then owed him about two thousand dollars; and I was also in debt to my father, to whom I conveyed the remaining half of my patent for two thousand dollars. Having parted with my whole title, and having no means for manufacturing machines, I was much embarrassed and did not know what to do. My brother, Amasa B. Howe, suggested that my invention might succeed in England, where, if patented, it would be wholly under my control; and on my behalf, with means borrowed of my father, my brother took my third machine to England, to do the best he could with it. He succeeded in selling my machine and invention for two hundred pounds in cash, and a verbal agreement that the purchaser should patent my invention in Great

Britain in his own name; and if it should prove successful, to pay me three pounds royalty on each machine he made or sold under the patent. He also agreed to employ me in adapting my machine to his own kind of work at three pounds a week wages. The purchaser obtained a patent for my machine in England, and I went to London to enter his employment. I then made several machines with various modifications and improvements, to suit his peculiar sort of work, and they were put to immediate use; but afterwards we ceased to be friendly, and I was discharged from his employment.

"In the meantime my wife and three children had joined me in London. I had also, at the suggestion of another person, endorsed a hundred pound note, on which I was afterwards sued and arrested; but I was finally released on taking the poor debtor's oath. By small loans from fellow mechanics, and by pawning a few articles, I managed to live with my family in London, until, from friendly representations from some American acquaintances, the captain of an American packet was induced to take my wife and children home to the United States upon credit. I was then alone and extremely poor in a foreign land. My invention was patented and in successful use in England, but without any profit to me, and wholly out of my control. In the spring of 1849, I was indebted to a Scottish mechanic for a steerage passage, and I returned to the United States, poorer, if possible, than when I left. On my return I found my wife and my children very destitute; all their personal effects, save what they had on, being still detained to secure payment for their passage home.

"My wife was sick, and died within ten days after my arrival. During my absence in England, a considerable number of sewing-machines had been made, and put in operation in different parts of the United States;

some of these by the procurement of the friend to whom I had sold half of my American patent, or under rights derived from him, but most of them infringements of my patent.

"Having obtained from my father, in the summer of 1849, an agreement to re-convey to me his half of my patent, I tried to induce the friend who held the other half to join me in prosecuting our rights against infringers, but he declined to do so. After failing to make any satisfactory settlement with the infringers, who well knew my poverty and embarrassments, I filed a bill in equity against one of such persons, and made my friend a party defendant also, in order to bring him into court as co-owner of my machine. After this he joined me in a suit at law against another infringer. In this case the validity of my patent was fully established by a verdict and judgment at law. After several transfers of the half share sold my friend, I purchased it back about five years ago, and I am now sole owner of the American patent." *

Such is Howe's modest narration of his struggle from the time he conceived the idea of a sewing-machine through till he had established his rights by a series of costly and vexatious law-suits. The narration has all the elements of a romance. The outrages which he was obliged to endure from the English robber who secured for a song his invention, and then turned him loose to starve; his life in the garrets of that great city with wife and hungry children; the benevolence of the "Scottish mechanic" who advanced the then starving, but future millionaire, the money to pay his passage home to the United States; the wife and children found destitute; the death of the faithful wife who had shared all his sufferings, but who was destined to share none of

* *Belgravia.*

his splendid triumphs; the unfaithful friend; all these are elements of a life which is almost exceptional in its character, in the humbleness of the beginning, the severity of the contest, and the splendor of its termination.

He is kind in that he glosses over, or does not mention at all the men who treated him so scurvily. The Englishman who bought his machine substantially for nothing, and then swindled him on the promised royalty, and finally turned him out to starve, was named William Thomas, and lived, and may yet live, in Cheapside; and it may be that there are many in that country who are of the opinion that he was the inventor of the sewing-machine, and that to him are due the credit, the ingenuity of the invention. The false friend by whose "procurement" the patent was infringed during Howe's absence, was George Fisher; and the man who finally, at the last moment, assisted him with money to prosecute his suits, was George Bliss, a capitalist of Massachusetts; although he had so little faith in the movement that he had to be secured by a mortgage on the farm of the father of Howe.

He does not in his modest account of himself say that after losing his place in London with Thomas that he was reduced to the direst necessity; that he built another sewing-machine at that time which was worth fifty pounds, and which, for the purpose of getting bread, he was forced to sell for five pounds; for a note for five pounds, which he succeeded in getting "shaved" for four pounds. When on his return from England, he landed in New York, he had less than sixty cents in his pocket and was obliged to work in a machine-shop; and it was on money sent him by his father that he was able to go and visit his dying wife, reaching her but a few moments before she died.

So far as money can compensate for suffering, Howe has been abundantly repaid. So far back as 1867, his royalty on sewing-machines had reached the sum of over two millions of dollars.

The extent to which ingenuity has been employed on sewing-machines, and their attachments, may be shown by the fact that some three thousand five hundred patents have been taken out in this country alone with reference to this new element of industry. In all, there are something over two dozen different kinds of sewing-machines in use, and by which all possible species of needle-work is done. They hem and bind; they quilt, plaid, tuck, cord, braid, embroider, ruffle; they sew the soles of boots; they make button-holes; in brief, they do all that the needle can do by hand and very much more.

The amount of elaboration which has been expended on the sewing-machine is almost endless. There are no less than some seventy different kinds of stitches which they make, such as the running stitch, the back, fast, chain, coiled-loop chain-stitch, knotted-loop chain-stitch, etc., with a single thread; then there are some twenty made with two threads, and still others with three threads; and in addition to these there are stitches for button-holes, for fancy work, and for other purposes. The names of particular machines, named after certain firms, have literally become household words. There are the Howe, the Singer, the Wheeler and Wilson, the Weed, the Florence, the Grover and Baker, the Domestic, the Wilcox and Gibbs, the St. John, and others whose names do not suggest themselves.

The machine for use in the manufacture of shoes was not invented until about 1861. It is said that the McKay machine consumed three years time, and more than one hundred and thirty thousand dollars in its

invention, and according to industrial reports, it has sewed more than two hundred and fifty million since it came into use in the United States, not counting those in other countries. Knight is authority for the statement that one operative with this machine has been known to sew over nine hundred pairs of boots and shoes in a day of ten hours, and that the average of operatives is from five hundred to seven hundred pairs a day.

There has been a large number of patents taken out for motors to drive the sewing-machine. There are several in which hydraulic engines and water-wheels are used; still others employ engines for the use of gas, steam, and air; there are perhaps half a hundred in which springs are the power; there are a few in which weights are utilized; some in which the weight of the operator supplies the power; and others in which the pendulum is made available, and at least one in which the power is obtained from a wheel turned by shot.

There is still a machine which does not sew either cloth or leather, but books. There are some twenty patents on book-sewing-machines, the first being taken out by Tanner, in 1862. They perform the work necessary for the sewing of the backs of books, and in in some instances use wire in place of thread. They are in wide use, but have not yet supplanted hand-work, as is the case with the sewing-machine for cloth.

An eminent mechanician, Knight, says: "If required to name the three subjects of invention on which the most extraordinary versatility of invention has been expended, the answer should be without hesitation, the sewing-machine, the reaping-machine, and breech-loading fire-arms. Each of these has thousands of patents, and while each of them is the growth of the last forty years, it is only during the last twenty-five years that they have filled any notable place in the world. It was

then only by a combination of talents that any of these three important inventions was enabled to achieve any remarkable success. The sewing-machine, previous to 1851, made without the admirable division of labor, which is a feature of all well-constructed factories, was hard to make, and comparatively hard to run. The art of *assembling*—first introduced in the artillery service of France by General Gribeauval in 1765, and brought to proximate perfection by Colonel Colt in the manufacture of his revolver at Hartford, Conn.—has economized material and time, and has improved the quality as well as cheapened the product. There is to-day, and has been in fact for some years, more actual invention in special machines for making sewing-machines than in the machines themselves. The assembling system—that is the making of the component parts of an article in distinct pieces to pattern, so as to be interchangeable, and then putting them together—is the only system of order. How else should the Providence Tool Company execute their order for six hundred thousand rifles for the Turkish government? How else could the harvesting machine companies of Springfield, Ohio, turn out an equipped machine every four minutes, each working day of ten hours? Or, how else could the Singer Machine Company of New Jersey make six thousand per week." *

It is impossible to give anything like an accurate estimate of the value which the sewing-machine has contributed to the world. As long ago as 1859, Prof. Renwick stated under oath that the saving in labor then amounted to over nineteen millions of dollars per annum; Wheeler and Wilson, in 1863, made an estimate that the value of the labor performed that year by the

* *Mechanical Dictionary.*

sewing-machine, was three hundred and forty-two millions of dollars! When one includes the part which the sewing-machine played in the late civil war, it will be seen that the annual value in 1864 and 1865 must have been even greater than this extraordinary amount. What may be the value of the annual product of the sewing-machine at the present time is something which can be only wildly guessed at, a work for which the reader is just as well prepared as the writer, or anybody else who does not have on hand the figures from which to draw his conclusions.

It is justly claimed that without the aid of the sewing-machine it would have been impossible to have kept in the field the vast armies which the government put in the field during the late war. These countless tents, garments, haversacks, cartridge-boxes, shoes, blankets, sails—how could they have been produced without the sewing-machine? One day during the war, at three o'clock in the afternoon, an order from the War Department reached New York by telegraph for fifty thousand sand-bags, such as are used in field-works. By the next afternoon, the bags had been made, shipped, and started southward. *

Much more might be said of the sewing-machine; but to say more would be in the nature of surplusage. In every family throughout the country its form may be seen, and with its musical click it tells a story more eloquent than any which can be told in words. It should be said of this machine that it is one which has taken its place in the world with but little if any of the opposition which labor-saving contrivances usually encounter. Either its introduction was so rapid that there was no opportunity for the organization of hostility, or else

* Parton.

it impressed itself on the classes most interested, as being something which would not injure them. It is very possible that the sempstress class saw that by no possibility could its condition be made any worse; and that any change must be for the better. And, in truth, the sewing-women were benefited. The introduction of the sewing-machine has so increased the demands for the products of the needle, that the wages of employés have been much better than they were before, when all classes of this work were done by hand. In every sense has the sewing-machine proved itself a benefit. It has vastly increased the domain of production; it has given work to three where one was employed before.

CHAPTER XXXIII.

CAOUTCHOUC, OR INDIA RUBBER.

CAOUTCHOUC is defined as a "vegetable substance obtained from incisions made in several plants affording a milky juice, as the *Urceola elastica*, a tree of tropical Asia; the *Ficus elastica*, a species of fig in Nepaul; and especially the *Siphhonia elastica*, a euphorbiaceous plant of South America. It is white at first, and assumes the dark shade usually possessed on exposure to smoke. It is impermeable to water, tenacious, elastic, unalterable by exposure to air, fusible at one hundred and fifty degrees, and soluble in ether and the essential oils."

Vulcanized caoutchouc is defined as "caoutchouc compound with a small proportion of sulphur, by which it is rendered hard and elastic like horn; so called because subjected to a high degree of heat during the process of manufacture.,

India rubber is precisely the same as caoutchouc, it being simply a name which is in common use.

There are some people who have a general sort of a belief that gutta-percha is either caoutchouc or something akin to it. This product is defined as a "concrete juice produced by various trees found in the Malayan archipelago, especially by the *Icosandra gutta*. It becomes soft and impressible at the temperature of boiling water, and on cooling retains its new shape. It

dissolves in oils and ethers, but not in water. In many of its properties it resembles caoutchouc, and it is extensively used for many economical purposes."

It is a somewhat singular fact that while the caoutchouc has been known for considerably more than a century and a half, its utility has only been known within the last forty or fifty years. It was in 1736, that there was some scientific examination made of this product; but in a certain sense, it was known long even before this period. Herrera, in writing an account of the second voyage of Columbus, speaks of an elastic substance of which the aborigines of Hayti made a ball with which they played certain games, a ball which had a most marvelous elasticity. These balls were made of the gum of a tree, were very light and without much bulk.

In his work, *Monarquia Indiana*, published in 1615, Torquemada describes very exactly the caoutchouc tree found in Mexico. The natives would extract the juice from the plant, and pour it over their own bodies until hardened, and then they would strip it off, and convert it into the shape desired. They also used it to manufacture balls for games, and for various other purposes. By means of heat they extracted an oil which, Torquemada asserts, was regarded as an excellent emollient, and a lubricant. Mingled with cocoa it was regarded as a desirable beverage; it was also used to aid digestion; it arrested hemorrhages, and for this purpose was taken internally. In its concrete form, the *ulli*, as the natives called it, it formed an armor that could resist the thrust of a spear, and turn the point of an arrow. One of the amusements of the higher classes was to place a species of stockings of ulli on the feet of the public dancers, and then derive enjoyment from the clumsy movements, and the frequent tumbles of the victims. Torquemada

winds up his account by saying that, "our neighbors, the Spaniards, impregnate their mantles with ulli for the purpose of keeping out the rain; it is certain that this gum marvellously resists water, but it cannot resist the action of the sun." *

The first accurate knowledge which science had of caoutchouc was afforded by the French naturalist, La Condamine, in 1736. During that year, the Academy of Sciences of Paris, with a view of settling the disputed questions connected with the form of the earth, its flatness at the poles, etc., sent out two grand expeditions—the one to the polar regions, under Maupertis; and the other to the equator, under the lead of La Condamine. While in Peru, La Condamine made some very elaborate examinations of the natural products of the country. In his report to the Academy, he mentions the existence of a very singular resin, which is put to many uses by the natives, and is taken from trees in various parts of America. The natives use it for flambeaux which give a clear light, and emit a smoke which is not unpleasant; they also make shoes of it which do not admit water; they construct balls from this material, which can be thrown any distance, which yield when under pressure, and at once resume their shape when the pressure is removed; they also make rings which can be used as bracelets, or even as necklaces, so great is their elasticity; they make of it pear-shaped bottles from which the contents are emitted when the bottles are squeezed in the hands, thus becoming veritable syringes, one of which, filled with water is presented as a matter of politeness to each guest at the close of the meal. It is from this use of the gum that comes the name *pao de xeringua* (wooden

* Volume II., page 663.

syringe) which was the name by which, for a long period, caoutchouc was known among the Portuguese, and from which came the name of *seringario*, in later times of those who collected the caoutchouc from the forests of the borders of the Amazon. *

Charles Marie de la Condamine, who introduced this most valuable natural product to the civilized world, was born in Paris, January 28, 1701, and died in the same city February 4, 1774. He was finely educated, and at the age of eighteen he entered the army, and served under his uncle, the Chevalier de Cources, during the siege of Rosas, where he exhibited exceptional gallantry. He soon after gave up the military profession, and joined an exploring expedition to the coasts of Asia and Africa; and in 1735, he made his expedition to South America; and in 1736, he gave his account to the public of his observation made on caoutchouc, the first specimens of which he is credited with introducing into Europe. He was made a fellow of the Royal Society of London; he did much to introduce innoculation in France as a preventive against small-pox; and wrote a large number of treatises on geography, natural history, physics, and the like. He was a man of fine natural abilities, which were highly cultivated; he was a scientist and a poet, and died greatly respected, leaving a name behind him which is yet fresh in the scientific world.

He communicated what he had learned in regard to the strange resin to a French engineer, named Charles Fresneau, who was located, during La Condamine's visit, in French Guyana. He tried to get some information from the Paran Indians, but they either had none, or refused to communicate it if they had any. In time, by a little scheming, he succeeded in finding out

* *Dictionnaire d' histoire Naturelle.* De Bomare.

the proper tree, and with the juice, he succeeded as well as the Indians in making bottles, shoes, and other articles from the gum. During the course of his experiments, Fresneau had dissolved the gum in a fat-oil, but with the result that it lost its elasticity. A French chemist took up the difficulty, and succeeded in dissolving it so as not to impair its elasticity, by the use of ether as a solvent, and then ran it in molds in the shape which he desired. Macquer, after his experiments, seemed to have a prevision of the value of the new product, for he said that its solidity and elasticity, and the property which it has to resist so many dissolvents, render it particularly valuable material for flexible pipes in mechanical appliances.

At the time of Macquer, towards the end of the eighteenth century, surgery had begun to make use of the new material for the construction of what are known as "sounds," and which at once received warm commendation as being less painful and far more safe than the instruments heretofore in use.

In 1770, Dr. Priestly, of London, gave evidence of the extent to which the new material was known in that country, for in the preface to a book which he had just issued, he said: "Since this work was printed off, I have seen a substance excellently adapted to the purpose of wiping from paper the marks of a black lead pencil. It must, therefore, be of singular use to those who practice drawing. It is sold by Mr. Hairne, mathematical instrument maker, opposite the Royal Exchange. He sells a cubic piece of about half an inch for three shillings, and says it will last for several years." It is hence that comes the name of India rubber. It may be noticed that India rubber has cheapened considerably since the date when a piece of the size of half an inch square sold for a dollar and fifty cents.

As early as 1790, in both France and England, springs were made of caoutchouc, and also some ligatures, and tubes, the latter being formed by the rolling of some of the material around a glass cylinder, and uniting the fresh-cut edges by pressure. In 1791, Peal, an Englishman; in 1792, Besson, a Frenchman; and in 1811, Champion, also a Frenchman, undertook to apply caoutchouc to water-proofing garments; but none of them met with any success. In 1813, John Clark, an Englishman, took out a patent for air-beds, which were double-cased, the inner one being inflated and rendered air-proof by the application of a solution of caoutchouc in spirits of turpentine boiled in linseed oil. In the same year a patent was issued in this country to Jacob F. Hummel, of Philadelphia, for a varnish of gum-elastic, for the purpose of making clothing water-proof. It is also claimed that a patent was issued in 1797, to an Englishman named Johnson, for rendering cloth water-proof by covering one side with a varnish made of India rubber dissolved in equal parts of oil of turpentine, and spirits of wine, and sifting over the surface silk, wool, flock, and other substances.

All these patents and experiments seem to have been abortive, as it was not till about 1820 that invention began to discover any very valuable properties in the new product. In that year, an Englishman named Nadler began to cut the India rubber into a thread so fine that it could be woven in with cotton; and about the same time, at Greenwich, a manufacturer named Barnard employed, for the preservation of marine cables, used under water, a preparation of caoutchouc. But the real era of the utility did not commence until a Scotchman named Mackintosh entered the field as an inventor. In fact, it may be said that, at this period, the real utility of caoutchouc was confined to the rubbing out of marks made by black lead pencils.

Mackintosh fabricated a water-proof garment which spread his name all over civilization, the garment taking the name of the inventor. The article of clothing was composed of a layer of India rubber on cotton stuff, and was so constructed as to be always elastic in warm weather, and to preserve its color without radical change.

Before explaining the invention of Mackintosh, a word may properly be said as to the difficulty which caoutchouc had up to that time presented when attempts were made to utilize it for water-proofing and the like. In the regions where the sap of the caoutchouc is produced, there appears to be no difficulty in the water-proofing of garments by the mere application of the raw sap. The same could have been done in Europe had there been any way in which the sap could have been transferred from Brazil without any change in its character. Such could not be the case. The sap for exportation was placed in hermetically-sealed jars; and during the passage it became solidified, concreted. In order, then, to secure the film of caoutchouc necessary for spreading over cloth, the mass must be dissolved. As before said, the Frenchman, Macquer, dissolved in ether; but the cost was too great for industrial uses. Barnard, of Greenwich, dissolved the raw product in a volatile oil, and then obtained the caoutchouc by distillation. This also was so costly that it was not available in the ordinary industrial pursuits.

Mackintosh was favored by chance, as is shown by a brief sketch given by his son of the circumstances which led to the invention of the Mackintosh. He says: "Upon the introduction of coal-gas into Britain for the purpose of lighting apartments and the streets of towns and cities, the manufacturers of the article found that the tar and other liquid products resulting from the process accumulated upon their hands, in the shape of a

most disagreeable and inconvenient nuisance. Mr. Mackintosh, chiefly with a view to the production of ammonia to be employed in the manufacture of cudbear, entered, in 1819, into a contract with the proprietors of the Glasgow gas-works, to receive for a term of years the tar and ammoniacal waters produced at their works. After the separation of the tar into pitch to suit the purposes of the consumers, the essential oil of naphtha is produced; and the thought occurred to him of its being possible to render this also useful, from its power as a solvent of caoutchouc or India rubber. By exposure to the volatile oil named naphtha, obtained from the coal-tar, he converted the substance into a water-proof varnish, the thickness and consistency of which he could vary according to the quantity of the naphtha which he employed in the process. Mr. Mackintosh obtained a patent for this in 1823."

The Mackintosh garment was a great improvement on what had gone before; but it had a fatal defect. It could not be adapted to extreme cold; it would stiffen; not many years after its invention, an American came over with a process which drove the Mackintosh out of existence. But the Scotch inventor had a long run of it; and made from his accidental discovery both fame and fortune. How far his use of a volatile oil to dissolve the caoutchouc was antedated by Bernard need not be examined; for he was the first to use a dissolvent which was at once cheap enough for industrial uses, and which answered the purpose sought.

In 1820, a very noted name began to come before the commercial world, that of Thomas Hancock, of London. He was connected for many years with the "rubber" trade, and both on account of his enterprise, and for some other reasons which will be mentioned later, he is one of the most prominent figures connected with the

development of caoutchouc during its earlier history. In 1820, he took out a series of patents covering various processes and improvements in the manipulation of the raw material; one of these was for the application of caoutchouc as wrists of gloves, straps for trousers, braces, belts, garters, laces for boots, etc. He was beyond all question a very ingenious operative; when he encountered a practical difficulty, he worked at it patiently until he was able to secure a remedy. One of the difficulties which he met was in the waste which attended his manufacturing processes. There was no means by which the cuttings could be utilized. In a work which he published he says: "These discouragements were very vexatious for a time, as my means were but slender. Although I was making way, I could perceive that unless some mode could be found to unite not only the waste cuttings, but also a large proportion of the material as imported (which was so uncouth in form and irregular in surface and size, that it could at present be turned to no useful account), my object would not be attained. My mind being solely directed to this subject, I saw the prospect of new applications, to an enormous extent, of a substance, with the properties of which I was daily becoming more and more conversant. I did not give up the pursuit; the object I had in view seemed within my reach by what I had already done, but the object itself I could not yet grasp." *

He discovered a process, which he kept for a long time a secret, by which he was able to take the remnants and reproduce them in a solid mass. He invented a machine in which the odds and ends were put and torn in pieces by revolving teeth. The place being hot, this, and the motion, made the remnants homogeneous, and

* *Origin and Progress of India rubber, etc.* Thomas Hancock.

they came out in the shape of a solid ball which could be manipulated as desired. Something of the same process is in use to-day, save that it is more complicated, more rapid, and more effective.

Let us pass on some twenty years, and take up an incident in the career of Hancock which is worthy of note, especially among American readers. In that year was discovered the famous process named "vulcanizing," and the matter is so important that it is deemed worthy of some extended attention. First, let us have the English account of the invention of the process: "The history of the discovery of this process, called by Mr. Brokledon 'vulcanizing,' is highly interesting. In 1842, he showed Mr. Hancock pieces of rubber brought by a person (note this, a *person* from America) from America, which were said not to stiffen by cold, nor to be much affected by solvents, heat or oils. The smell of sulphur was perceivable in these samples. However, nothing seems to have come of it.

With the idea of rendering caoutchouc unaffected by cold, etc., he toiled away after business hours in his laboratory at Stoke Newington, lighting his own fires, for he never allowed any one to enter his laboratory. Noticing the change of appearance, for which he could not account, in some experimental scraps of caoutchouc containing sulphur, he tried numerous experiments in this direction, saving the most likely specimens, and testing by means of ice their behavior under the influence of cold, as an indication of a change. Knowing that if rubber be submitted to the heat necessary to melt sulphur, viz., two hundred and forty degrees Fahrenheit, it would not be sufficiently high to injure it, he began by immersing slips in a sulphur bath, noticing the action from time to time, and at last obtained a specimen of a black color and a hard and horny

character. . . . He at once saw that by blending the sulphur with caoutchouc by means of rollers and masticators, the material could be dissolved and used for water-proofing, or moulded into any form to any degree, and capable of being wrought with tools. His patent was enrolled on the twenty-first of May, 1844, his experiments previously being repeated for him by Professor Graham, and Mr. Arthur Aitkin." *

Here is the American account in regard to the real discoverer, Charles Goodyear, a native of Connecticut. He made a good many efforts to improve the quality of caoutchouc by the use of nitric acid. "It did not satisfy the hopes of Goodyear, and in 1838-9, he made at Woburn, Massachusetts, many experiments with compounds of India rubber and sulphur. In January, 1839, he observed that a piece of India rubber, mixed with ingredients, among which was sulphur, when accidentally brought in contact with a red-hot stove, was not melted, but that in certain portions it was charred, and in other portions it remained elastic, though deprived of adhesiveness. The material was vulcanized; *i. e.*, it had undergone the change produced by a high degree of artificial heat. Thus was presented the germs of the two forms of vulcanized India rubber, now commonly known as the soft and the hard compounds. From this time until his death, the process of vulcanization occupied his whole attention, but he reaped no adequate pecuniary reward for his labors. The Goodyear patents, now more than sixty in number, have been very expensive in themselves, and still more so from the necessity of defending and protecting them against infringers.

"The first publication of the process of vulcanization was Goodyear's patent for France, dated April 16, 1844. The French law is that the patentee shall put

* *India rubber or Caoutchouc.* James Collins, F. D. S., Edinburgh, etc.

and keep his invention in public use in France within two years from its date. Goodyear endeavored to comply with this and all other requirements of the French laws, and thought he had effectually done so; but the courts of France decided that he had not complied with every particular, therefore his patent had become void. In England he was still more unfortunate. Having sent specimens of vulcanized fabrics to Charles Mackintosh & Co., (the "Co." being Hancock), in 1842, and having opened with them a negotiation for the sale of the secret of the invention or discovery, one of the partners of the firm, named Thomas Hancock, availing himself of the hints and opportunities thus presented to him, rediscovered, as he affirms, the process of vulcanization, and describes it in a patent for England, which was enrolled on May 21, 1844, about five weeks after the specifications and publications of the discovery to the world by Goodyear's patent for vulcanization in France. The patent of Hancock, held good according to English law, thus superseded Goodyear's English patent for vulcanization, which bore date a few days later. Goodyear, however, obtained the great council medal of the exhibition of all nations at London in 1851, the grand medal of honor of the world's exhibition at Paris in 1855, and the cross of the Legion of Honor, presented by Napoleon III." *

The French authorities have an opinion in regard to this matter. They are of a belief to the following effect: In 1842, Europe began to receive from America India rubber shoes which were perfectly adapted to daily use. They did not harden in winter; when cut, their surfaces would not unite, their elasticity was without limit, and the impermeability absolute. These new articles obtained in England and France an immediate and

* *Am. Cyclopædia.*

immense success. French manufacturers did not know how to explain so marvellous a transformation of the gum elastic. In fact, the maker who sent the shoes from America, Charles Goodyear, kept his process a secret.

Was it the fault of the inventor that he neglected to take out patents in all countries? Whatever may have been his reasons, Charles Goodyear continued to manufacture his shoes by a process known only to himself. But he had counted on keeping the process a secret without counting on the eagerness and the jealousy of his commercial competitors.

There lived in Newington, near London, a manufacturer of caoutchouc named Hancock, who was as celebrated for his specialties in England as Goodyear was in the United States. When he learned of the discovery of the American inventor, and his determination to keep the process a secret, he gave himself no rest until he had penetrated the mystery. It was through chemistry that he discovered the secret. He had recognized in the ashes, left by the combustion of some of Goodyear's shoes, some sulphates, and by a process of distillation he discovered the presence of natural sulphur. Starting out from this indication, he soon succeeded in discovering the secret of Goodyear.

The American inventor was thus completely dispossessed of his discovery by his English rival. Hancock at once proceeded to take out the patent which Goodyear had neglected. As his application was in regular form, as he described in it all the various operations connected with the process, he obtained it at once, preventing the unfortunate Goodyear from even exploiting his discovery in England. The French narrative concludes as follows:

"There are some persons who seem to be pursued by

fatality. Charles Goodyear, who experienced so terrible a rebuff in England, was destined, a few years later, to perish in a foreign country, in a manner at once deplorable and wholly unforeseen. He came to Paris in 1860, to attend to some commercial business. But he succeeded so badly that he used up all his available resources and was finally arrested on a warrant for debt and thrown into the debtors' prison at Clichy. One day, at the first glimmer of dawn, he opened his window in order to obtain a breath of fresh air. He did not appear to know that the opening of his shutters at this early hour was forbidden, at that period, to the prisoners of Clichy. The sentinel called to the prisoner that he would have to quit the window. But Charles Goodyear, not understanding a word of French, understood nothing of the injunctions of the sentinel. The soldier reiterated four or five times his warning; the prisoner did not move from the casement. Then the guard, having exhausted his summonses, and obedient to his orders, leveled his gun at the uncomplying prisoner, fired, and the inventor of vulcanized caoutchouc fell dead across the sill of the window." *

Very fortunately, the portion of the French account which relates to the alleged death of Goodyear is not true. The great inventor died in the Fifth Avenue Hotel in New York city. The victim of the tragedy may have been a brother of Charles Goodyear, Henry Goodyear, who died somewhat mysteriously in Paris in 1860.

There is, however, even reason to doubt that any member of the family met with such a fate; at least relatives of the family profess never to have heard of any such occurrence, although they admit that "Henry met with a very sudden death while in Paris."

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* *Merveilles de l' Industrie.* Louis Figuier.

From these accounts, there would seem to be no doubt whatever that Goodyear was the sole inventor of the process of vulcanizing caoutchouc, and that its introduction into England was through what was at least a very disingenuous act on the part of Hancock. His first idea of the vulcanized rubber was from a specimen sent him by Goodyear with a view to selling him the secret; he took advantage of the opportunity to analyze the sample, to get at the secret of the process, and then to patent it as an original invention.

The life of Goodyear has many points of interest. He came of an inventive family, his father having made many improvements, more especially in agricultural implements. He was given a fair common school education, then learned the hardware business, and entered into a partnership with his father, and a little after, in 1826, he removed to Philadelphia, and commenced in the hardware business on his own account; the first establishment in the country, according to his biographer, for the sale of domestic hardware in the country. The Philadelphia business was not a long-lived one, and soon went under; one of the results being that Goodyear spent a great portion of his time for the next ten years in the debtors' prison. The result may have been in the end a benefit to him, for the reason that he was thrown out of business, and as a matter of necessity, as well as of inclination, he was driven to invention as a means of securing a subsistence for himself and family.

At this period, 1834, rubber goods began to attract a good deal of attention; Goodyear among others became interested, and by accident was led to enter on a course of experiment. Happening to be in New York, he passed the establishment of the Roxbury India Rubber Company, where he purchased a life-preserver, which he took home, and improved the construction of the tube

through which it was inflated. On his next visit, he showed his improvement to the agent of the company, who was struck with Goodyear's ingenuity, and entered into a conversation with him, in the course of which he said that the rubber companies were in serious trouble. The whole business, he assured him, was on the eve of ruin, and that a very large compensation would be given any one who would devise a way to overcome the difficulties they had met in the manufacture and the preservation of their goods. The Roxbury company had manufactured a large quantity of shoes and other goods in the fall and winter of 1833 and 1834, and had sold them at good prices; but in the succeeding summer the greater part had melted, and twenty thousand dollars' worth of goods had been returned to them decomposed, and emitting so offensive an odor as to render it necessary to have them buried in the earth. Other companies were in the same condition, and what rendered the matter more serious was the fact that it required a test of a year or more—the return of warm and cold weather—before they could know whether their goods could escape decomposition.*

The case was a serious one. Clothing made of the rubber, as then prepared, would become as stiff as iron in the winter, and would melt and rot in the heat of the summer. In a case in which Daniel Webster afterwards appeared as counsel for Goodyear, he gave his experience with the rubber of that period. "I well remember that I had some experience in the matter myself. A friend in New York sent me a very fine cloak of India rubber, and a hat of the same material. I did not succeed very well with them. I took the cloak one day and set it out in the cold. It stood very well by itself. I

* Parton.

surmounted it with the hat, and many persons passing by supposed they saw standing by the porch the Farmer of Marshfield."

It was at this time that Goodyear was called on to take up a matter concerning which he knew nothing, which involved millions of dollars; and with which, as he had no chemical education, he was not fitted to grapple. He was a bankrupt; he spent a good deal of his time in prison; and he had no reserve to fall back on while engaged in the investigation. In fact, it was while in prison that he commenced the solution of the problem. His first accomplishment was the mixing of magnesia with the gum, by which he obtained a white color, and a compound which seemed able to stand heat. Unfortunately these qualities were not lasting, for after a time it began to soften and ferment the same as the other rubber in use, and which had proved a failure.

Meanwhile, for the support of his family, he commenced the manufacture of rubber articles, the principal one being shoes, as these required but little skill. His wife and children, as the latter became large enough, assisted in the manufacture; and in this way his family was preserved from want; at the same time, as he could, he gave attention to the problem of improving the quality of the material. He tried various experiments, but met constantly with failure. This continued so long that friends who had been backing him, became discouraged, and withdrew their assistance. This so reduced him that he was obliged to sell what little furniture he had to pay the loans which he had made; and then he found a cheap and retired boarding-place for his family in the country, leaving as security for the rent of the cottage which he had occupied, a quantity of linen woven by his wife, and which was soon after sold at auction. One of his children died, another was sick for

a long period; but he retained his courage, and as soon as he could, he went to New York, there to resume his efforts to solve the rubber problem.

Here a friend supplied him with a small room, and a druggist agreed to trust him for drugs. He became reduced to very nearly destitution; but he worked on, and from time to time made some improvement which seemed to be the desideratum, and from the sale of which he gained now and then some money. He even, at one stage of his investigation, made an entire suit of clothes, which he wore. It is related that a gentleman one day asking another how he might recognize Goodyear, was answered: "If you meet a man who has on an India rubber coat, cap, stock, vest, and shoes, with an India rubber purse without a cent in it, that is Goodyear." By the use of nitric acid, he succeeded in procuring some excellent results; so much so that he received a patent for the process, and was complimented in autograph letters from President Andrew Jackson, Henry Clay, and John C. Calhoun.

His discovery at this stage appears to have been a method of "curing" the caoutchouc, by destroying its adhesiveness; he made of it bandages for the dressing of wounds, material for maps, cards, and engravings, upon which he had executed some beautiful specimens of printing. Soon after he obtained a partner, and they commenced the manufacture of his cured gum; they were on the high-road to fortune, when there came a general financial revulsion, and in company with thousands of others, the new firm went to the ground.

Once more he neared absolute starvation. He pawned all his furniture for food, and relates that he once pledged an umbrella with Vanderbilt to secure some ferry-tickets to the city. He struggled along in the depths of poverty for some time, and finally went to

Boston, where he once more "got on his feet," and began to make money by the sale of his new material, which was manufactured for piano covers, and similar articles.

In 1838, he purchased for a small sum a patent for a process of "curing" rubber by the use of sulphur rubbed on the surface of the material, but which had the defect that it did not alter the interior. This sulphur process was one that had been discovered by a German chemist named Leudersdorff, and which he had given to the world for the benefit of those engaged in the manufacture of rubber goods.

Goodyear proceeded to make some experiments with the sulphur process. He was getting along swimmingly; he had concluded a contract for a large number of mail-bags for the government; and had completed them, when he was suddenly brought to a complete knowledge of the value of his process by finding that the mail-bags were all rotting; and that his process of curing had not affected any thing more than the surface of the material. In almost the twinkling of an eye, the inventor was thrown back into the depths from which he had been so long in emerging. In a moment, all his friends deserted him; he was now simply a visionary inventor. The people were exasperated with him, and would not listen a moment to his wishes to continue in his "foolish and wicked schemes." He must give it all up, and go back to the hardware business, and drop this reckless waste of time and money in useless experiments. Thus said the world.

He turned his back to the world, and went on with his experiments.

"It was generally agreed," he said, "that the man who could proceed further in a course of this sort was fairly deserving of all the distress brought on himself,

besides being justly debarred from the sympathy of others." He closed up all his business, turned his parlor into a workshop, and aided by his family, carried on the manufacture of shoes as a means of support, while he resumed his experiments with the sulphur process.

One of the first things which happened to him was the discovery of the final steps necessary to the perfecting of the process of vulcanization; and yet he was doomed to pass through two years of destitution before he began to reap any reward from his discovery; two years, compared to which all the worst years of his life thus far had been luxurious opulence. The final hint which gave him what he sought for was the result of the sheerest of accidents. He was sitting in the kitchen one evening with a piece of gum in his hand, which he happened to touch against the hot stove while absorbed in conversation. The gum melts at a very low heat; he noticed that although the place where his piece touched the stove was very hot, that the gum, instead of melting at the point of contact, had charred like leather without melting, and without leaving a sticky surface. It flashed over his mind that he had found the secret of curing the gum; he nailed the piece outside the door, where it remained during a night of intense cold. When he took it down in the morning, it was flexible; the discovery was made, and the existence of vulcanized rubber was assured.

There are those who say that Goodyear is entitled to no credit; the use of sulphur, they say, was not his discovery, but that of a German chemist; the effect of a high degree of heat on the gum came from pure accident; that had he not made the motion whereby the piece of gum touched a hot place on the stove, vulcanized rubber might be unknown at the present day. There is just a little truth in this, but not very much.

There are a thousand men who might have touched the gum against the stove, just as he did, and nothing would have come of it. The credit to which he is entitled is that he detected the change which the material had undergone, and had the intelligence to take advantage of it. In fact, he is entitled to quite as much honor as he would be had he reasoned out the effect of heat in advance, and had produced a perfect result the first time that he undertook to put his theoretical conclusions into practice.

His suffering during the two succeeding years is simply incredible. He was without a dollar of reserve. The prejudice against rubber was intense, as in every case it had proved a disastrous failure. Every one of his neighbors, his relatives and friends believed that he was a fool; that he was a visionary, who was wasting his time in an effort to accomplish what again and again had been absolutely demonstrated to be an impossibility. He was charged with neglecting the interests of his family, with permitting them to suffer for lack of food and comfortable clothing, while he wasted his time in trying to do what they knew could not be done. He was urged to give up his futile and visionary search, and return to the hardware business; and for this purpose he was offered all the capital he needed.

In a trial which afterwards took place with reference to his rights, there was some testimony which will afford a fair insight into the condition of the Goodyear family. In 1839, the witness testified, he found them extremely destitute. "They had sickness in the family. I was often in, and found them very poor, very destitute both for food and fuel. I know they had to go into the field and woods to glean fuel. They had none. They had nothing to buy any with. This was before they boarded with us, and while they were keeping house. They told

me they had no money to buy their bread with from one day to another. They did not know how they should get it. The children said they did not know what they should do for food. They dug their potatoes before they were half grown, for the sake of having something to eat. Their son Charles, eight years old, used to say that they ought to be thankful for the potatoes, for they did not know what they should do without them. We used to furnish them with milk, and they wished us to take furniture and bed-clothes in payment rather than not pay for it. At one time they had nothing to eat, and a barrel of flour was unexpectedly sent them."

At one time, in the winter of 1838–40, he awoke in the morning to find that his cabin was snowed in, and that there was not a morsel of food or fuel in the house. He had exhausted the patience and charity of his neighbors, and he was at an utter loss as to what he could do. Finally it occurred to him that, the day before, he had met a man, living some miles away, who had greeted him, as they passed each other, with something like kindness. On the strength of this he started to visit the man, and after many hours wading through the heavy drifts, he finally, in a condition of complete exhaustion, reached the place. His expectations were realized; the man not only relieved his present necessities, but gave him enough to carry his family through the rest of the winter.

It is simply a record of a series of unvarying struggles and destitution, imprisonment, and suffering, including death and sickness in his family, from this period until 1841, when a capitalist named William Rider, of New York, offered to furnish the money to bring out his inventions, and to manufacture them for public sale. Even now his luck followed him, for hardly were they established in business when Rider failed, and he was,

for a brief time, again thrown on his own resources. Finally, DeForest, his brother-in-law, a capitalist, and woolen manufacturer, took Goodyear under his protection, and opened the manufacture of India rubber goods under Goodyear's patents. The value of the "plant" may be inferred from the fact that it cost DeForest to establish Goodyear in business forty thousand dollars, a sum which he was never able to repay him. *

For a time Goodyear had some prospérity, but none of any duration. He went to England and found that his patent had been forestalled by the indefensible action of Hancock; for it is asserted by his biographer that Goodyear sent over some specimens of his vulcanized product to Hancock, with a view of selling him the process, and the latter, by chemical processes succeeded in getting at the secret of the preparation, which he then patented in his own name. Goodyear exhibited his goods at the World's Fair, held in London, in 1851, and obtained for them the highest class of medal given exhibitors; but he did not succeed in convincing Hancock that he should make restitution for the profits of the theft of his process. He went to Paris and exhibited his goods in 1855, at the Exposition, for which he received a grand medal of honor, and the cross of the Legion of Honor; but this did not prevent his becoming involved in his business relations, and being arrested and held in jail for sometime as a debtor. He returned to America, struggled along for a time in ill-health, and died July 1, 1860, about as poor in this world's goods when he left life as when he entered it.

The discovery of the process of vulcanizing caoutchouc very soon made the manufacture of rubber goods one of the principal industries of the world. It is

* Rev. Bradford K. Pierce.

estimated that there are over five hundred uses to which it is applied, and that not less than one hundred thousand persons in this country and Europe are engaged in its manufacture. In some form or another, it has made its entry everywhere. It has become omnipresent. In the household, on railways, in the machine shops, in wearing apparel—everywhere it is in use. The air or water-beds and pillows of the hospital are of vulcanized rubber; the over-shoes, the water-proofs, the blanket of the soldier, are of the material which Goodyear gave to the world. The springs which relieve the jolting of the cars are made from this product; so are the combs of the toilette room, the handles of the brushes and combs, hose of all sizes, horse-blankets, carriage-aprons, buckets, door-mats, weather-strips, clothes-wringers, belts for machinery, steam-packing, life-preservers for use on water, and scores and scores of other things which cannot be enumerated without a trade-list.

Parton draws the following lively picture: "Some of our readers have been out on the picket-line during the war. They know what it is to stand motionless in a wet and miry rifle-pit, in the chilly rain of a southern winter's night. Protected by India rubber boots, blanket, and cap, the picket-man performs in comparative comfort a duty which, without that protection, would make him a cowering and shivering wretch, and plant in his bones a latent rheumatism to be the torment of his old age. Goodyear's India rubber enables him to come in from his pit as dry as when he went into it, and he comes in to lie down with an India rubber blanket between him and the damp earth. If he is wounded, it is an India rubber stretcher, or an ambulance provided with India rubber springs, that gives him least pain on his way to the hospital, where, if his wound is serious, a water-bed of India rubber gives ease to his mangled frame, and

enables him to endure the wearing tedium of an unchanged posture. Bandages and supporters of India rubber avail him much when first he begins to hobble about his ward. A piece of India rubber at the end of his crutch lessens the jar and the noise of his motions, and a cushion of India rubber is comfortable to his armpit. The springs which close the hospital door, the bands which exclude the drafts from doors and windows, his pocket-comb and cup and thimble are of the same material. From jars hermetically closed with India rubber he receives the fresh fruit that is so exquisitely delicious to a fevered mouth. The instrument case of his surgeon, and the store-room of his matron, contains many articles whose utility is increased by the use of it, and some that could be made of nothing else. In a small rubber case the physician carries with him and preserves his lunar caustic, which would corrode any metallic surface. His shirts and sheets pass through an India rubber clothes-wringer, which saves the strength of the washerwoman, and the fiber of the fabric. When the government presents him with an artificial leg, a thick heel and elastic sole of India rubber give him comfort every time he puts it to the ground. In the field, this material is not less strikingly useful. During the late war armies have marched through ten days of rain, and slept through as many nights, and come out dry into the returning sunshine with their artillery untarnished and their ammunition not injured, because men and munitions were all under India rubber." *

* *North American Review*, July, 1865.

CHAPTER XXXIV.

GLASS AND ITS MANUFACTURE.

WHEN glass was discovered is a question which has never been satisfactorily answered. There is a popular account of its origin, which is as incorrect as are the popular notions in regard to the discovery of steam by Watt, or of the locomotive engine by Stephenson. The popular rendering of the discovery is to the effect that some Phœnician sailors, who had on their vessel a cargo of either salt or soda (usually spoken of as nitrum), landed on the banks of the river Belus, in Palestine. They could find no stones on which to rest their cooking utensils above the fire, and thereupon, they brought some of the pieces of nitrum, made the fire under them, and proceeded to cook their provisions. The heat melted the nitrum, and also the sand on which they rested, with the result that the fused composition ran off in a liquid and transparent stream. This account is given by Pliny, and in this he is corroborated by Josephus and Strabo. Tacitus, A. D. 60, simply says that "there is found at the mouth of the Belus, a river which empties into the sea of Judea, sand which, mingled with nitrum and submitted to the action of fire, will produce glass." There is no reason to believe the narration of the Latin author of the accidental discovery of the Phœnician sailors, more especially in view of the fact that the heat which would be produced in the open air

would fall very much short of the temperature required for the fusing of the materials entering into the composition of glass.

There is excellent reason for thinking that the origin of glass dates back not less than three thousand years before the Christian era. All the modern authorities unite in the statement that it was known to the Egyptians many centuries before our era. There has been discovered at a place known as Beni Hassan, a tomb, which is supposed to date from the reign of Osortasen I., on which is a painting which represents two glass-blowers, Thebans probably, who are seated on each side of a lighted furnace, and have in their hands the blow-pipes which are in use for the inflation of molten glass. In this picture, there is a small bulb of glass on the end of each of the pipes; in another painting, the two have inflated the molten material until it has assumed the form of a jar.

In the same age, images of glazed pottery were common; proving the mode of fusing, and the proper proportions of the ingredients for making glass to have been then known. Sir J. G. Wilkinson adduces the instance of a glass bead, about three-quarters of an inch in diameter, and of the same specific gravity as our crown glass; this relict Captain Hervey found at Thebes, and its date is proved by its bearing the name of the monarch who lived one thousand five hundred years before Christ. Such was the skill of the Egyptians in glass-making that they counterfeited the amethyst and other precious stones worn as ornaments for the person. Winckelmann, a high authority, is of the opinion that glass was employed more frequently in ancient than in modern times; it was used by the Egyptians even for coffins; they also employed it not only for drinking vessels, but for mosaic work, the figures of deities, and

sacred emblems, in which they attained excellent workmanship, and surprising brilliancy of color." *

According to the same authority, a patent for the making of glass coffins was issued in England in 1847, or several thousand years after the same thing had been in use by the Egyptians.

The glass-bead above referred to, had on it, in hieroglyphics, the following inscription: "The good deity, Ramaka, beloved of Athor, Protectrice of Thebes." The Ramaka thus referred to was the widow of an Egyptian monarch who reigned during the eighteenth dynasty, or one thousand five hundred years before the Christian era. In fact, the working of glass in Thebes can be traced with considerable exactness to a date 3,370 years B. C. There is also no question as to the knowledge of glass by the Hebrews, but when and where obtained is not known.

According to Strabo, the Greek philosopher and author, who lived half a century before Christ, and Pliny, who lived soon after the beginning of the Christian era, there were some very famous glass-works at Alexandria; and according to some other ancient authorities, the art of cutting, of coloring, and gilding, were known some 400 years B. C., with the result that some very artistic results were produced. Glass articles in those early days were very costly, and almost occupied in the quality of value, rank with the precious stones and metals. "Vases and cups, some enameled and beautifully cut and wrought with raised figures, and some remarkable for the brilliancy of their colors," were furnished to the Romans; among whom the manufacture of glass was not introduced till the time of Cicero, about a century B. C.

In the ruins of Nineveh, glass remnants have been

* *Egyptian Glass.* Apsley Pellatt. 1849.

ANCIENT EGYPTIAN GLASS BLOWING. (651)

found, such as lenses, vases, and bottles, and the like, but, according to Drone, there have been found no indications that glass was used in windows. In the palace of Nimrud, Nineveh, and now preserved in the British museum, was found a small vase of transparent green glass, on which are engraved the outlines of a lion, and the name and titles of the Assyrian monarch, Sargon, who lived more than seven centuries B. C.

During the reign of Nero, which was during the last part of the first century of this era, the manufacture of glass reached a high development. It is related that so valuable were the glass products of this period that Nero paid two hundred and fifty thousand dollars for two cups, which were not very large, and constructed of that clear glass which resembled crystal. In fact, so valued was the new product by the luxurious Romans, that glass cups superseded those of gold and silver. It was by the Romans that the celebrated Portland vase was constructed, and which was found in the sixteenth century in a marble sarcophagus, near Rome, and is credited with being one hundred and thirty-eight years older than the Christian era. It is claimed to be the finest specimen known of the kind; it is ten inches high, and is composed of two layers of glass, the under one being of a deep blue color, and the other of an opaque white. There are some raised figures on a background of blue, which are thought to be representative of the marriage of Peleus and Thetis. It was purchased by the Duke of Portland, from whom it received its name (being otherwise known as the Barberini vase, the name of the palace in which it remained for over two centuries); the cost to the duke being a little over fifty thousand dollars. It was placed in the British Museum; and as will be remembered, it was broken by a lunatic visitor into innumerable pieces. It was carefully joined together

afterwards, so that the fact of its having been broken is not recognized by the ordinary observer.

Commencing with the thirteenth century and extending through several others, the Venetian glass-works led the world in the quality of their manufactures. The Venetians were followed by the Bohemians, who have retained their positions to the present time as among the most artistic manufacturers of glass in the world. It is probable that mirrors originated among the Venetians, although it was a long time before the manufacture of them became a popular one. It was of a certain kind of Venetian glass that it was believed that if the walls of a cup made of it were touched by a drop of poison, they would break; although there is nothing on record to prove the truth of this belief. It was also among the Venetians that originated the modern style of glass-engraving, the work at the outset being done with a diamond point. "With few exceptions, the design was a roughed surface intaglio, which, contrasted with its white transparent ground, had a lace-like delicacy of effect, especially if improved by traced polished lines, occasionally introduced, to give the relief of light and shade." The Bohemians and Venetians had cylindrical drinking glasses curiously painted in vitrified colors, with coats of arms called *vidre come.*

The jealousy of the Viennese lest their art should fall into the hands of foreigners, may be inferred from the fact that stringent laws were passed in regard to the retention of the art at home. Three of the sections of the law thus passed were as follows:

"If a workman transports his art to a foreign country, to the detriment of the republic, it will send him an order to return.

"If he fail to obey, the persons nearest him in blood shall be imprisoned.

"If, notwithstanding the imprisonment of his relatives, he shall not return, an emissary shall be sent to kill him."

These laws were made by the Council of Ten in 1547; in 1762, they were reaffirmed, and some rigorous additions were made to them, and were directed against those who should divulge the secrets of the manufacture, and against working-men who were going to establish themselves in a foreign country.

There were many glasses manufactured by the Venetians and Bohemians which have since rarely or never been excelled in the originality of design, exquisite finish, and delicacy of tracery. What was called Millefiore glass was especially ingenious in design and artistic in construction. It consisted of a large variety of ends of fancy-colored tubes, "cut sectionally, at right angles with the filigree cone, to form small lozenges or tablets; and these, when placed side by side, and massed together by transparent glass, had the appearance of an innumerable series of flowers or rosettes, for ornamental vases." One of the most noted of their products is the *vitro di trino*, an original design, and which is a fine lace-work with "intersecting lines of white enamel or transparent glass, forming a series of diamond-shaped sections; the centre of each has an air-bubble of uniform size, executed with almost the precision of engine lathe-turning."

In 1666, the manufacture of glass was introduced into France, and more than a century earlier into England. The first articles manufactured in the last-named country was window-glass, which, however, had been in use sometime before. Some authorities place the date of the introduction of window-glass into England as far back as the seventh century. The manufacture of glass was introduced into this country in 1622, at

Jamestown, Virginia; and, in common with several other enterprises, was wiped out by the massacre by the Indians. Several others are said to have been started during the seventeenth century, but the first permanent one was erected in Temple, N. H., by a man named Robert Hewes, in 1780; and from that date to the present time, the increase of manufactories has been rapid, until now, when this country has its due share of this class of industry.

What is glass? It has been remarked that it is very singular in the fact that it is a transparent substance, composed of certain bodies, not one of which is transparent taken by itself. The shortest definition of glass is that it is composed of sand fused with certain alkalies. Chemically, it is defined as a "substance or mixture, earthy saline, or metallic, brought by fusion to the state of a hard, brittle, transparent mass, whose fracture is conchoidal." An example or two will afford an idea of the composition of some varieties of glass. The French window-glass consists of 69.25 per cent of silica (sand); 11.30 of soda; 17.25 of lime; 2.20 of alumina.

French plate-glass consists of 72.00 per cent of silica; 17.00 of soda; 6.40 of lime; 2.60 of alumina; and 1.90 of oxide of iron.

Flint glass consists of 44.30 per cent of silica; 11.75 of potash; and 43.05 of oxide of lead.

French bottle-glass has 60.00 per cent of silica; 3.10 of potash; 22.30 of lime; 8.00 of alumina; and 4.00 of oxide of iron.

Crystal, and other forms of glass are slightly different in their composition; but there are, in the main, two kinds or classes. One of these is known as window-glass, and includes sheet, crown, and plate-glass; and the other is flint-glass, which is used for decanters, and

the like, and also for the lenses of telescopes and microscopes. The former is simple—the latter, compound glass.

The process of glass-making is a curious and interesting one, although not elaborate as to the number of processes. After the materials have been fused, articles of glass are fashioned by one of two methods, that of blowing, or that of casting. In preparing the material for melting, the sand and other substances are thoroughly ground and mixed, to which composition is added about one-third of its weight in broken glass. This is placed in the melting-pot, more being added as the contents melt down, until the pot is filled with the melted metal, and then the heat is increased until the metal "boils" and all bubbles have disappeared, which indicates that all the carbonic acid gas has made its escape. When the contents of the pot have reached what is believed to be a perfectly homogeneous state, the metal is allowed to cool until it reaches a viscid condition, when it is ready for the operations of the blow-pipe.

In the making of bottles—the largest of the products of glass manufacture—the better class are blown into shape. The working-man gathers a portion of the soft metal on the end of his blow-pipe, and hollows the metal by blowing into the mass, and gives it shape by holding it in various positions; in the case of bottles of less consequence, there is a mold composed of two parts which are opened to admit the soft metal and then are closed, and give shape to the exterior of the bottle, the operator, meanwhile, with his breath hollowing the mass and forcing it to fill the cavities of the mold.

There is also another machine which has an iron bed, into which is a cavity hollowed out corresponding to the exterior of a tumbler; into this the proper quantity of metal is placed, and then by means of a lever, a plunger

is driven down into the cavity, with the result that the metal is forced to fill the mold, the plunger just corresponding on its exterior surface to the inner surface of the tumbler.

Both crown and sheet-glass are the product of the blow-pipe, with the difference that the former is first blown into the form of a hollow sphere, and the latter into the form of a hollow cylinder. When the workman has produced the sphere, a small opening is made in the end furthest from him, and then the globe is twirled until it is flattened out into a circular disk. In the case of the production of the sheet-glass the metal is blown into a long, hollow cylinder, which, when reduced to the proper thinness, is cut with a diamond point along the line of its length, and is then flattened in an oven through the effect of heat.

After this it is polished by the aid of machinery, and the irregularities of its surface are removed, and then, if perfect, it remains a single sheet; or if there be flaws, it is cut in smaller panes, such as its perfect composition will permit.

The manufacture of plate-glass is conducted in a manner quite unlike that of the making of the other forms of window-glass. A description of the plate-glass manufactory of a leading establishment in England shows that it is of unusual size, compared with other classes of factory buildings. The entire length of the building is three hundred and thirty-nine feet, and its width one hundred and twenty feet, making it one of the largest structures of the kind in the world. The raw material is exposed to an intense heat in the pots for some sixteen hours, and then is allowed to cool to a certain viscidity. It is then poured on the casting-table, which consists of an immense slab of cast-iron. At the sides of it are guards of the height which it is

desired to have the thickness of the plate. The slab is very carefully cleaned, and then the molten metal is poured on it, and as soon as this is done, a copper roller is pushed over it, leveling it down even with the top of the guard. Immediately after, the plate is drawn into an annealing oven close at hand, and which is heated to a dull redness. The plates are cast, and placed in the oven until it is filled, and then the oven is closed, and the contents left for several days to cool. After being thus far completed, they are ground by machinery so as to obliterate all inequalities of the surface, and are then polished by rubbers worked by machinery, and the use of some powder, generally the red oxide of iron.

There is no difficulty in the construction of plate-glass to give it any desired curvature; a form is made of the desired shape, and on this the sheet of plate-glass is laid and subjected to sufficient heat to make it pliable. In this condition, it settles down and adapts itself to the form on which it rests, and which, as a matter of course, it retains when it becomes cold.

The production of the various kinds of colored glasses in the market is simply owing to the mixing of the metal with some one of the metallic oxides, as for instance, with oxide of iron, which colors the glass either green or yellow, according to the nature of the oxide; with protoxide of copper which gives a green result, while the suboxide of the same metal colors the glass red. By thus changing the oxides all possible colors are produced, and varying the quantity used, numerous variations in individual colors are obtained. Thus, according to the quantity of oxide of silver which may be used, the glass will have all the stains from a delicate lemon to a deep orange.

The uses of glass are innumerable; and to its existence are due some of the most marvellous advances of

the ages. So far as drinking vessels are concerned, they are simply in the nature of a convenience; the world could get along very well without them. It is in the domain of optics that glass has performed its greatest work, for here, dropping the role of the merely convenient and the decorative, it has taken the highest rank in the department of the useful, for it has given us both the microscope and the telescope.

In the article on the telescope, information is given as to the invention and progress of this instrument, so that nothing more needs be said in this direction; but the growth of the lens is something which will bear some special attention. The telescope never amounted to much in comparison with its present value until this century was well on its course. The difficulty was that the manufacture of glass had not reached a stage of advancement which permitted the construction of masses of glass of sufficient purity. The glass from which a lens is to be made should be homogeneous and free from all defects. Up to the beginning of this century the largest lens produced was only four inches in diameter. Large rewards were offered by scientific bodies for a lens even of this diameter which should be wholly free from all imperfections. The reward was secured by an optician named Guinand. Somewhat singular is the fact that Guinand was not a glass manufacturer, and knew nothing of mathematics; despite this he succeeded in constructing a lens nine inches in diameter.

Guinand was the son of a carpenter, who was born in Neufchatel, Switzerland, in 1745, and who died in 1825. He was apprenticed to an optician, and in 1785, he commenced the manufacture of lenses. During the latter part of his life, he gave his entire attention to the manufacture of lenses, and telescopes of great power and size, every part of which was made by his own hands.

For a long time his method of making lenses was a secret which he refused to divulge during his life-time; and it was not known till it was communicated by one of his sons, after his death, in 1828. About this time lenses were made of crown and flint glass of twelve to fourteen inches in diameter; and in 1851, Chace & Co., of London, exhibited a disk of flint glass which was twenty-nine inches in diameter, and which weighed two hundred pounds; and later the same firm exhibited one of the same dimensions which was made of crown-glass.

One of the most powerful lenses made was one furnished by a London manufacturer, some years ago, which was three feet in diameter, made of flint-glass, and with a focal distance of six feet and eight inches. The rays collected and refracted by this lens were thrown on another with a diameter of thirteen inches, and a focal distance of twenty-nine inches. When the solar rays from this combination were turned on wood, it was consumed instantly; water flashed at once into steam; gold was melted in four seconds; silver in three; copper in twenty; flint in thirty; and carnelian in seventy-five seconds.

Some very fine work has been produced in this country by the Cambridge firm of Alvan Clark and Sons; the senior member being, like Guinand, the Swiss optician, self-taught. Mr. Clark constructed the object-glass of the refracting telescope in the Dearborn Observatory, in Chicago, the glass having a clear aperture of eighteen and one-half inches. He also made for the refracting telescope, at Washington, an object glass of twenty-six inches aperture, with a focal length of thirty-two feet and six inches. Mr. Clark claims that he can produce an object-glass with a clear aperture of five feet two inches, and seventy-five feet focal length. The amount of work involved in grinding these object-glasses

may be inferred from the fact that it required some thirteen months to grind, polish and finish the object-glass for the great equatorial telescope in the Naval Observatory at Washington.

The limit of telescopic lenses is not yet reached; but the advances made during the last fifty years of this century would almost force the conclusion that whatever may hereafter be done, to this period will belong the chief glories connected with the improvement of the manufacture of lenses.

A very interesting industry connected with glass is the production of stained-glass windows, and which is described as follows:

"In the first place, after a design has been drawn, in which the effect of the window as a whole can be carefully considered, cartoons of the figures and the ornaments are made of the exact size of the intended painting. And here it should be noted, that all the lines should be extremely clear, precise, and well-drawn, because it is from these that the workman, who is not usually himself an artist, has to convey on the glass the feeling of the artist. The cartoon, when completed, is laid down in pieces for convenience-sake on a table, and fastened with small nails. The glass-cutter then selects various colored glasses, which are required to be inserted in their proper places, so as to carry out the designs of the artist. For instance, a piece of white or yellow-tinted glass is cut in the shape of the face. If the figure be a small one, the hair is also included in this; and probably in the figure of a saint, the nimbus which surrounds the head may be included; while in larger figures, particularly in the earliest styles, the face was of glass of one tint, the hair of another, and the nimbus of one or more tints, different from either of these. Sometimes in the later styles, the hair, after the face was

painted and burnt in, was stained with the silver stain already described, so that when the glass was cleaned, it was of a yellow color. The outlines of the figures and ornaments are painted with a substance called ‘tracing-brown,’ made by mixing with a flux some oxide of iron, heating them together in a crucible and grinding the product to a fine powder, which is mixed with certain vehicles adapted to the particular use to which it is to be applied. Different fluxes are employed by different glass-painters; some contain borax, because such fluxes fuse more easily, and therefore cause the glass which is painted to be exposed for a less time, and to a lower temperature than when less flexible fluxes are used.

. . . “ Suppose it is desired to paint the outlines of a face, the glass is cut to the shape of the face in the cartoon; it is then laid, and the painter, seeing the lines through the glass, is able to trace them with brown paint upon its surface. . . When the face is finished, it is removed, and other portions of the figure, say a piece of the drapery, is proceeded with in exactly the same way; and so, by a repetition of this process in all parts of the figure, it is completed, and looks very much like a puzzle, the parts being put together on the cartoon before the work is finished, in order to see that the whole is harmoniously treated. In shading the hands, and those parts of the drapery which require it, a glass easel is used on which the figure is put together, and the parts made to adhere by wax, so that the artist is able, while painting, to form an idea by transmitted light of the effect which will be produced when the window is finished. The ornament is painted in a similar manner, but usually not with the same care in the details of its execution.” *

After the work is burned, or “fired,” the pieces of

* G. P. Bevans, F. G. S.

glass are united so as to form the required design by strips of lead; and then with some filling in, and such a disposition of the lead strips that they do not appear in their true character, the window-painting is finished.

Not the smallest use to which glass is put at the present day is in the manufacture of artificial eyes. In the manufacture of this article, the work is mainly done by the breath through a slender blow pipe, and the delicate manipulation of the artist. They are made from enamel, and by a delicate and ingenious process all the various parts of the eye, as to form and color, are so exactly reproduced that it is only the want of motion in the artificial article which enables one to detect that it is not Nature's own product. At present, the largest and possibly the most skillful manufacturers of artificial eyes are to be found among the French. Another branch of glass industry in which the French have obtained some wonderful results is the manufacture of artificial gems.

In this instance, the invention of the artificial gem is not of French, or even of modern origin. The Egyptians were famous in the production of imitations so good that it was only with great difficulty that they were distinguished from the genuine. Emeralds, sapphires, and hyacinths were among the Egyptian imitataions, and are frequently alluded to by the ancient writers as being faultless in their execution. It was not till the discovery of the "purple of Cassius"—a preparation of gold and bioxide of tin—in the seventeenth century, that was permitted the construction of imitation rubies; and since that period the work of imitation includes almost every form of precious stone. In this industry the French have led all the others. They have given the world "diamonds" of glass which would defy detection on the part of anybody save an expert.

There are innumerable other uses to which glass is

devoted, and an attempt to enumerate them would be no more than a simple catalogue. Glass in one form or another has made wonderful strides in modern utility, ornamentation, and luxury, within a comparatively brief period. It is almost impossible to conceive that modern civilization would be civilization without it. One of its broadest effects has been in the crystal palaces in which since 1851 the world has held its grand expositions. In fact, without glass one of these monstrous creations would be impossible for the purpose intended, for in no other material could be found the light-transferring qualities which are necessary in the construction of these monstrous enclosures.

In the production of plate-glass, France takes the lead of any other nation. Its annual product of plate-glass is some four or five million square feet; and of window glass, over fifteen million square feet. It makes some one hundred million bottles, and flint glass and ordinary table goods to the value of about six million dollars each year; the total value of its product being about fifteen million dollars. The English glass manufactories export each year glass articles to the amount of about six million dollars. Including "ware not specified," the United States has an annual product of about twenty million dollars; but of this amount over fourteen million dollars is credited to "ware not specified." In addition to the enormous amount manufactured here, we take over six million dollars' worth from Europe, over one-half of which is for crown, plate, and window glass; and nearly two-thirds of which comes from Belgium. The capital employed in glass manufacture, in this country, is in round numbers, over twenty million dollars; there being some twenty thousand hands employed, and some three hundred establishments in existence.

CHAPTER XXXV.

CONCLUSION.

THE amount of space covered in this book seems large, especially in the matter of type and paper. In fact it has advanced considerably beyond the dimensions of the average book; but it has been found impossible to employ less, and yet do justice to the object of the work. The discussion of inventions is one of the greatest magnitude, and were it treated exhaustively, far more would be written than is contained in the present volume. But exhaustive treatment of all the phases of invention has not been aimed at.

What has been intended, is to treat more especially, the great inventions, and their social and economical value. There are abundant minor inventions, many of which have been alluded to, that are not of sufficient consequence to invite discussion, and which in reality form no part of the scope of this work. To have included all of them, or even any considerable portion of them, would have encumbered the intent of the publication, and would have added nothing to its value. The masses have neither the opportunity nor the inclination to follow an examination of the kind through all possible elaborate and minute details. They prefer something which, in the briefest possible space, presents to them the more salient of the points under discussion.

It is believed that, in what has been rejected as well

as what has been selected, this book has taken the course which most efficiently answers the purpose designated—that of conveying to the reader the maximum of the most valuable information in the minimum of space. What has been written is believed to be that most conducive to public instruction, without, in the least, having adulterated the treatment with unnecessary matter, or reflections and conclusions not pertinent in their character.

It is thought that the perusal of this work may create a desire for specific investigation into the domain of mechanical appliances, than which there is none more inspiriting. In this direction there is a world, almost a universe, to be explored, and each step taken will reveal wonders undreamed of by those who have never before traveled over the route. There are millions of paths which may be followed in this investigation, few of which have known the feet of the masses, and along which have passed only the more adventurous and energetic of the world's explorers.

Not the least important of the contents of this work, is the attention which has been given to the lives of the inventors. In this direction, the world is sadly in need of information. In the cases of many there is nothing whatever known; in reference to others, there are prevalent grave misapprehensions, while to a minority there is extended an honor to which they are not in the least entitled. In the development of human progress, in invention as in other directions, the personality of the men and women who have been conspicuous as agents, is of the greatest value to the student. These persons constitute models for imitation, and their example acts as a powerful stimulant. For these reasons, a liberal space has been devoted to the *personnel* connected with inventions.

There is an element of the pathetic, the romantic, in the life of the inventors which has been presented. Often poor, illiterate, they have struggled into prominence, and attained success under circumstances which have shown that they were heroes. Often has it been found to be the fact that after laboring painfully for years to reach the desired end, some waiting adventurer, some intellectual pirate has stepped in, and in a moment deprived them of the efforts of a life-time. Goodyear underwent constant crucifixion during a long life, and died in poverty after giving the world an invention worth incalculable amounts of money.

Poor, old, half-blind Galileo, on his knees before the cardinal inquisitors, and solemnly abjuring what he knew to be true is, in view of the tremendous importance of his discoveries, a picture which stands out in bold coloring on the canvas of the ages. Poor John Fitch, broken-hearted, a recluse, and dying by his own hand in an obscure place far from the civilization, is as pitiful a spectacle as one ever finds in the pages of fiction. Gutenberg, chased from point to point; living in destitution, friendless, shutting himself out from the cruel world to protect his improvement; exposed to endless litigation, and dying in poverty and obscurity, is another tableau in the panorama of the lives of inventors, and is as touching for its wretchedness, and its display of unappreciation, as any of the more sorrowful events of life.

What is more calculated to awaken sympathy than Howe, in his cheerless garret in London, without food and employment, robbed by one who grew wealthy from his theft? Or what more pitiful than the same inventor, begging his way to the bedside of his dying wife, one who suffered with him all through his poverty and wretchedness, and lived to share none of the royal

compensation which soon after fell to the lot of the almost-exhausted inventor?

Very few of the men who have been instrumental in the discovery of an important improvement have reaped the reward of their labor. It has been stolen from them by others, the recognition has been extended to them when they were so broken down by age, disappointment, and opposition that they had lost the capacity to enjoy it, or else they have died, and their services were recognized only when they had become a memory.

Those who peruse this work will discover, if they read aright, that there is scarcely a single case in which the genesis of an invention is due to a single person. It has been shown—and the writer believes most conclusively—that invention is an evolution. No one man is shown to have invented the steam-boat, the steam-engine, printing, photography or any other of the great appliances which have been made the subject of examination. It has been shown that Fulton did not invent the steam-boat, Stephenson the locomotive, Watt the steam-engine, Daguerre the photograph, or Morse the telegraph. It is seen that always away back of the time of the alleged inventor, the invention has existed in some form, less developed, and that the work of the reputed inventor was simply more or less that of its development. In fact, there are but few of the inventions of the modern days that did not exist in some form in the very earliest periods of history.

What we have done since antiquity is to take known appliances, and age after age bring them nearer perfection. One inventor built a fire under a cylinder with water in it, and as the fluid was converted into steam, the piston was driven up; when he wished to lower the piston, he raked out the fire, and as the steam cooled, it was condensed, and the piston descended. Later, another man

found that it would be better to make the steam in a separate vessel; he admitted it into the cylinder, then shut it off, threw cold water on the cylinder to hasten the cooling, and in this way he made an improvement, and gained somewhat in speed over his predecessor. Later, another steam-user found that if a jet of cold water was thrown into the cylinder, when it was filled with steam, he could get the required condensation in still less time than by the usual process. Still later, there came another steam-user, who found that if he should let the steam escape into another vessel after it had done the work demanded of it, he would then condense it and save the cooling of the cylinder, and the time required in heating it again for the reception of the vapor.

Now here we have the progressive development of the condensation of steam in the cylinder of the steam-engine. Can it be truthfully said that any one of the men concerned in it was the inventor of the process of the condensation of steam? Not in the least; it is a clear case of evolution, and no one man concerned in it is entitled to the credit of the entire invention any more than a single link in a chain is entitled to be called the entire chain itself.

It is comforting to the patriotism of England to assert and teach that Watt invented the steam-engine, that Stephenson was the inventor of the locomotive, and to the Americans to assert that Morse invented the telegraph, and Fulton the steam-boat; but these countries are all the time flattering their self-love by a war with the facts. These men were instrumental in assisting in the development of the appliances with which their names are so prominently associated, but there is no ground for announcing them as the inventors. Stephenson improved the locomotive; it has been improved far more since his day than he improved on what

preceded him; why not, then, with equal justice may not the men who have advanced beyond him be claimed as the inventors of the locomotive? Philip Reiss employed the telephone, and Count Marcel, years before the advent of Gray, Bell, and Edison, announced how sound could be transmitted to a distance; and yet the last-named are litigating as to their right to be considered the inventors of the telephone. They are not the inventors; nor were Reiss or Marcel, although both antedated Gray and the others by many years. The former improved on what was known before them, and Gray and the others made some improvements over Reiss and the French electrician. All of them were simply engaged in the work of aiding in the evolution of invention.

It has been seen by those who have followed the line of thought in this work that there is no such thing as locating exactly any invention of prominence, in the remoter periods of the past. We have found that innumerable things, which are in use at the present time, were employed in some form in the earliest historic past, and that there are indications in the remains of the more ancient civilizations that very many of the appliances of to-day, and supposed to be modern, were known to nations thousands of years before the commencement of the modern era.

A case which illustrates this very fairly has been furnished by the investigations of an orientalist who spent some time in Gizeh, investigating as to the tools in use some four thousand years ago. He demonstrates that those used for cutting stone "were constructed with a jewel at the cutting edge." In a late paper, * the author says: "Solid and tubular drills, straight and circular disk-saws, and lathe tools were made with jewels set in

* *Engineering*, London.

metal. The lines of cutting on a granite core made by a tubular drill form a continuous spiral, the grooves being of a uniform depth and width throughout, showing that the cutting point was not worn as the work advanced. The regular taper of the core would indicate that jewels were also set on the outside and inside of the drill, thereby facilitating its removal. In some specimens of the granite the drills sank one-tenth of an inch at each revolution, and the pressure necessary to do this must have been from one to two tons. The skill of the workman and the capacity of the tool are illustrated by the clean path through both soft and hard material—no difference in the groove being perceptible, although it passes from a soft substance into quartz, subjecting the tool to an enormous strain. In plane substances the depth and width of the cuts indicate the successive strokes of the saw, and the course of the circular saw is proved by the regularly curved lines. The form of the tools was the same that experience has sanctioned at the present time. The scarcity of the diamond and the lack of strength in the sapphire and the beryl lead to the consideration of the conundrum. Nothing has been found about the metal of which the tool was made or of the method of setting the jewel."

Here are some very suggestive facts. The inferences are fairly drawn to the effect that in this particular branch of mechanical work, the ancients of forty centuries ago were as well provided with ingenious appliances as is the workman of the present day. If this be the fact in regard to stone-cutting, it may be concluded inferentially, that other appliances, equally ingenious, were not lacking in other branches of mechanical effort. In truth, when one reflects how advanced are the various civilizations of the ancient world, the conclusion is inevitable that inventions must have reached a high

condition of development; for, as has been asserted in this work, invention is the leader, and not the follower of civilization to a very considerable extent. Given human development and the existence of invention may be assumed with entire certainty.

There have been many speculations as to the "lost arts," and there are not wanting those who believe that the ancients were not only as far advanced as we in many important mechanical conditions, but that in many they excelled us. There is no doubt that they were able to do some things, of an artistic character, which we cannot reproduce; but it is equally certain that in the gigantic mechanical developments of modern times, such as are to be found in the electric telegraph, the railway, the locomotive, and the steam-ship, they were vastly our inferiors.

Passing the many interesting inferences connected with the growth of ancient civilizations, and indicating our own possible rise and decadence, it may be said that modern invention is none the less entitled to credit, although it may be charged with reproducing what had already had an existence. The man who invents something concerning which he has never heard as being in existence is to all intents and purposes an original investigator, and should be given the honor belonging to a first discovery. The modern inventor, without the smallest assistance, or hint from the ancients, has succeeded in reproducing substantially all that was known to the ancient world, and a vast amount in addition, and this long before there came any knowledge as to what was known or practiced by the ancients. In fact, it is only the later years of this wonderful age that have been able to determine with any degree of probability the true character of the ancients, including their advance in mechanical appliances. We first revolutionized the

later world, and then applied ourselves to finding out what was known to, and done by, our earlier ancestors.

From the very outset of this work, the names of civilization and invention have been inseparably coupled. It may be that, in a great many cases, necessity has given birth to invention; but it is to be noticed that generally invention preceded and did not follow great events. There has been usually an appositeness in the appearance of an improvement, as when gunpowder came into existence in Europe at a time when it could be of the greatest use in aiding to break up the intolerable tyranny of the feudal system. But it is worthy of notice that invention has not always waited until needed to perform its labor; it has, as it were, foreseen the necessities of man, and presented its results so that they might be present, and be made available when needed. It is in this direction that there is so much obscurity about the author of many inventions; the invention itsélf having been in existence, but not being wanted, has lain dormant until demanded, when some man of keen perceptions has developed it, and thereby has become credited with its discovery.

Whether invention has operated prematurely, or responded to an urgent demand, its value cannot be overestimated as to the part it has played in the development and the shaping of human progress. This has been shown step by step in the course of this work. If any man who reads what has occurred in mechanical development does not conclude that civilization owes more to invention than to any other agency, he fails to read properly the facts which are presented. There have been moral events which have revolutionized communities or nations, but, as a rule, such occurrences are the work of years, often of centuries. They have been the consequences of argument, of slowly-forming

convictions which have required generations for their germination, their growth, their ripening, their blossoming and their fruition.

But notice how a great mechanical improvement makes its way! A little over fifty years ago, there was no such thing as transportation by steam; to-day, there is a line of railway, and a train of cars to be seen on almost every square mile of civilization. Less than half a century ago communication by the use of electricity was a mere suggestion, a possibility, an amusement; to-day there are millions of miles of electric wires, and the uttermost parts of the earth are within talking distance of each other. Yesterday, there was no telephone save as a toy; to-day it is in universal use, and so wonted are the people to it that it seems as if it had always been in existence. Within the life-time of many not yet old, it required at least a month to cross the ocean, and those who crossed were comparatively few in number; to-day, we cross the stormy abyss in little more than a week, and those who cross annually are numbered by hundreds of thousands. The sewing machine has effected in less than a generation a revolution in labor greater than that effected in another direction by Luther in two centuries. In fine, the potentiality of invention cannot be disputed, nor can there be found in any other domain of effort a rival.

As to the future of invention, what can be said that will adequately describe it, if we suppose that the next half century will be as prolific of its results as have been the last half hundred years? If such should be the case, there is no language with which to depict its magnitude, no ideas of sufficient power to include its dimensions. There are many who are of the opinion that what has been accomplished within a few years is as nothing in comparison to what will be effected within

the next century. They say that marvellous as are the results of electrical advance, we are merely on the threshold of the domain of that science; and such may be the case. Almost any one can see that there are great possibilities in the department occupied by the electric energy. As a light it has just come into use, and there is every reason for believing that the time is not distant when it will form the sole light of the streets of cities, of public buildings, mines, submarine operations, factories, and everything of the kind.

Its capacity as a motor is being developed to an extent that promises undreamed of results. There is an opening in this direction which is almost without limit. It may supplant steam on the railways and steam-boat; it may be used to give motion to the machinery of factories as it is now so frequently employed for the driving of the smaller classes of machinery. As coal becomes scarcer, the waterfalls may be utilized for the driving of railway trains, the operation of farm machinery, and for a thousand other purposes which need not be enumerated. In other directions there is equal opportunity for an advance, some of which may be surmised, and others of which cannot even be guessed at. That by the aid of electricity people may in a short time be able to see each other as they converse at the telephone is one of the near possibilities of invention. The transmission of *fac simile* messages will perhaps be so improved that it can be done in an instant, so that even the great newspaper may be reproduced at distant points with the same rapidity that it is now taken off the perfected press.

In fine, in view of what invention has done, there is no absurdity in imagining that it can do almost anything which is now regarded as impossible, or at least improbable, in the domain in which it is operating.

The same may be said of almost all other departments

of invention. Having shown itself comparatively unlimited in its reach and its accomplishments, there is no reason to doubt that it will continue in the future as it has continued in the past. An appreciative man should rejoice who has been permitted to live in this age. It is particularly the age of invention; it is the most resplendent age of which the world has any knowledge, and what is most surprising in this view of it is that, great as it is, there is no reason why we should conclude that we have reached more than the mere beginnings of the majestic development which is to follow.

THE END.

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